MODELLING TECHNICAL MANPOWER

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by

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To my wife Rosemere,

for her support during the production of this thesis.

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ABSTRACT

This thesis describes the technical manpower problem of New Zealand industry and explains the importance of defining the behaviors of technically qualified people for the solution of the problem.

Idealized operational definitions are developed for designing, planning, leadership, organising, acquaintance and management. The practical application of the definitions for designing questionnaires about the work performed by technical personnel is illustrated by a description of a survey conducted on behalf of the New Zealand Engineering Industry Training Board.

Finally, some brief comments on technical manpower adaptation are presented.

For easy reference the conclusions are presented on a set of blue pages (Chapter twelve). Each conclusion contains a reference to the chapter in which it was inferred and is printed on a blue page at the end of that chapter.

CONTENTS

LIST OF FIGURES

LIST OF SYMBOLS

General

A, B	a purposeful individual (or subject).
C	a goal-seeking or purposeful individual (or subject).
C_i	an available course of action for a subject in a purposive state.
M_1	a message.
O_j , O_k	a possible outcome for a subject in a purposive state.
s	a state variable.
S, S'	choice environment of a purposeful individual in a purposive state.
t_i	a moment of time.
$t_1 - t_2$	a time-period.
X	an object, event or their properties.

Psychological Properties of an Individual

DF_{ij}	degree of familiarity a subject has with a course of action C_i relative to an outcome O_j.
DI_i	degree of intention a subject has for a course of action C_i.
DI_j	degree of intention a subject has for an outcome O_j.
DK_{ij}	degree of knowledge of a subject of a course of action C_i relative to an outcome O_j.
DU_{ij}	degree of understanding of a subject of a course of action C_i relative to an outcome O_j.
E_{ij}	efficiency of a course of action C_i relative to an outcome O_j for a subject.
EV	expected relative value of a subject in a choice situation.
EV_j	expected relative value of a subject for outcome O_j in a choice situation.
$L(DI_i)$	level of degree of intention of a subject for the available courses of action.

$L(E_{ij})$ level of efficiency of available courses of action for outcome O_j.

P_i the probability that a subject will produce a course of action C_i.

$P(O_j)$ the probability that outcome O_j will occur.

V_j the relative value of an outcome O_j to a subject.

β_{ij} amount of control a subject has over a course of action C_i relative to an outcome O_j.

β_i amount of control a subject has over a course of action C_i relative to a set of n outcomes.

β amount of control a subject has in a purposeful state relative to a set of m courses of action and a set of n outcomes.

Interpersonal Properties of Individuals

$A_{ij_{AB}}$ amount of acquaintance an individual A has with another individual B and a course of action C_i relative to an outcome O_j.

$F_{a_{ij_{AB}}}$ amount of familiarization an individual A has for another individual B and a course of action C_i relative to an outcome O_j.

f_A acquaintance function of one individual for another.

f_{F_a} familiarization function of one individual for another.

f_L O-leadership function of one individual for another.

f_L^* generalized O-leadership function of one individual for another.

f_m management function of one individual for another.

f_m^* generalized management function of one individual for another.

f_o^K K-organising function of one individual for another.

f_o^{K*} generalized K-organising function of one individual for another.

f_o^U U-organising function of one individual for another.

f_o^{U*} generalized U-organising function of one individual for another.

$L_{j_{AB}}$ amount of O-leadership an individual A has over another B for an outcome O_j.

$M_{j_{AB}}$ amount of management an individual A has over another B relative to an outcome O_j.

$O^{K}_{ij_{AB}}$ amount of K-organising an individual A has over another B for a course of action C_i relative to an outcome O_j.

$O^{U}_{ij_{AB}}$ amount of U-organising an individual A has over another B for a course of action C_i relative to an outcome O_j.

Sets

$\{C_i\}$ set of available courses of action in a choice situation.

$\{O_j\}$ set of possible outcomes in a choice situation.

$\{p_f\}$ set of essential properties of a concept.

$\{p_i\}$ set of essential properties of an image.

$\{p_x , p_1\}$ set of essential properties of an object.

$\{x\}$ set of signs and instructions of a technical language.

The
best model
of
a technical man
is
HIMSELF.

But,
he
would not
fit
between
the covers of
this
book.

My thoughts
on
his thoughts
are
offered instead.

G. A. Britton.

CHAPTER 1

INTRODUCTION

There are many problems in the New Zealand engineering industry regarding the training and utilization of technical personnel. For example, industry spokesmen say the training given to graduate engineers does not suit their requirements. The situation is made worse because many companies, particularly the smaller ones, will not employ inexperienced graduates : the training of these people occurs mainly in the public sector. Experience gained in that sector is not wholly appropriate for nor transferable to the private sector.

Complaints are also received from young graduate engineers. Some of them working in the industry say they cannot obtain the practical experience needed for registration. A shortage of suitably qualified engineers to supervise the work of trainee engineers makes this problem more acute.

The New Zealand Government too, has its problems regarding technical manpower. It is concerned with providing adequate numbers of the various types of technically qualified people required by the existing industry: a difficult task to accomplish. It also has the problem of establishing industries with technologies new to New Zealand. Past attempts at this have not been successful because the New Zealand technical personnel have not had the training and experience to be competent in their new jobs.

Professor McCallion, through his association with the Engineering Industry Training Board, became aware of the problems confronting the Government and industry. He believed a major step towards their solution would be achieved if scientific models of technical staff could be developed. This research project was initiated for that purpose.

A surprising feature of the project is it mainly involves the social sciences but both Professor McCallion and the author are engineers. Obviously, undertaking a project of this nature for a Ph.D. thesis must be justified: there are three reasons why the author agreed to it.

Firstly, obtaining a sound appreciation of the social sciences was important to the author whose ambition is to be an operational researcher. One of the skills of an operational researcher is to have a good knowledge of disciplines other than that in which one specializes.

Secondly, it was intended to use an extremely powerful conceptual system proposed by Ackoff and Emery (1972) as the basis for the project. They comment on their work by saying:

...it should be emphasized that what is attempted here is only secondarily intended to provide systems-oriented scientists and engineers with additional quantitative tools and techniques for their kits; it is primarily intended to provide them with a new kit for new and old tools and techniques. We try to provide a new way of thinking about and dealing with behavioral variables by constructing well-defined measures, not by attempting to add to the already numerous ill-defined indexes of such variables. Our efforts will not make it easy for others to deal rigorously and objectively with the richness, subtlety, and complexity of human behavior, but, if successful, they will make it possible. (p.11).

With their system the author believed sufficient progress could be made in the social sciences to produce a thesis of acceptable standard.

Thirdly, the author would have a greater understanding of the work performed and problems faced by engineers than a psychologist or sociologist. This was considered an advantage for the task of modelling their activities; one which more than offset the lack of knowledge of social science techniques.

The initial aim of the project was *to develop a theoretical method to assess technical manpower requirements for jobs in an organisation.* The meaning of this definition and its ramifications for the researcher are discussed in detail in the next chapter. It is concluded that if this work is to be useful to the scientific community - and it is intended that it should - the research project as initially defined should be abandoned.

Chapter three explains how the research project was redefined; developing idealized operational definitions of several technical manpower activities is considered suitable work for a Ph.D. thesis. A discussion on defining is presented in Chapter four.

Chapters five to nine discuss and develop definitions of the concepts designing, planning, leadership, organising, acquaintance and management.

Chapter ten describes a survey which illustrates how idealized definitions and concepts can be used to design questionnaires about the work performed by technical personnel.

Thoughts on technical manpower adaptation are presented in Chapter eleven.

The thesis has been designed to be an efficient reference source for a variety of readers with different purposes. The abstract is printed on a yellow page for easy reference; and each chapter is self-contained, with important conclusions printed on blue pages at the end of the chapter. All these conclusions are combined and presented on blue pages as Chapter twelve.[1]

[1] *Footnote: The influence of Stafford Beer on this design will be apparent to readers familiar with his work.*

REFERENCES

ACKOFF, R.L., AND EMERY, F.E. *On Purposeful Systems.* London, Tavistock Publications, 1972.

CHAPTER 2

THE NATURE OF THE TECHNICAL MANPOWER PROBLEM

2.1 PURPOSE OF RESEARCH

The initial definition of this research project was *to develop a theoretical method to assess technical manpower requirements for jobs in an organisation.* Before the research problem can be formulated this definition needs to be clarified:

(1) *to develop a theoretical method:* it was intended to develop an explicit method which would produce objective models of technically qualified people, to replace the intuitive methods and subjective models of management consultants and the like.

(2) *to assess technical manpower requirements for jobs:* the reasons for assessing technical manpower requirements for jobs are:

(a) to control the movement of technical personnel into, within, and out of existing organisations,

(b) to design organisations using technologies familiar to New Zealand,

(c) to design organisations using technologies unfamiliar to New Zealand.

Technical personnel were restricted to qualified engineers. A qualified engineer was defined as:

(a) a person who was

  (i) a Registered Engineering Associate,

  (ii) a Registered or Chartered Engineer,

  (iii) a full member of a recognised engineering professional institution;

  or

(b) a person who had gained

(i) a University degree in engineering,

(ii) a New Zealand Certificate of Engineering or Draughting, or an equivalent overseas qualification.

(3) *organisations:* The research results were intended to apply to production organisations in New Zealand industry. However, as New Zealand is an industrially under-developed country it was thought the results might apply to other under-developed countries as well.

2.2 AIMS OF RESEARCH

The specific aims intitially agreed upon were:

(1) to define the technical manpower problem,

(2) to select a particular aspect of this problem for investigation; in particular, to produce a rigorous conceptual system from Paterson's (1969) decision band theory and show where it fits within the overall problem,

(3) to conduct a technical manpower survey for the New Zealand Engineering Industry Training Board,

(4) to incorporate some of my theoretical findings in the survey.

2.3 FORMULATING THE TECHNICAL MANPOWER PROBLEM

The technical manpower problem was initially conceived as an applied research problem. An understanding of it was essential if a theoretical framework for applied research was to be produced.

Ackoff (1962) has noted the requirements to formulate an applied research problem:

... any problem situation, and hence research-problem situations can be represented by the following equation:

$$V = f(X_i, Y_j)$$

where V = *the measure of performance or accomplishment that we seek to maximize or minimize.*

X_i = *the aspects of the situation we can control; the 'decision', or 'choice' or 'control' variables.*

Y_j = *the aspects of the situation (environment of the problem) over which we have no control....(p.28).*

...In applied research it is necessary to translate the decision maker's problem into a research problem. This requires a complete identification of the components of the decision maker's problem which are

(1) the decision maker(s),

(2) his (or their) relevant objectives,

(3) the possible courses of action,

(4) the context : those aspects of the problem environment which, though not subject to the decision maker's control, may affect the outcome of his choice of action. These may be

(a) 'acts of nature', or

(b) acts of other decision makers : reactions or counteractions (p.67).

Ackoff's scheme was used to identify the essential features of the technical manpower problem. As these are described the reader will become aware of the extreme complexity of the situation. This significantly influenced the work undertaken by the author.

The decision makers are the New Zealand Government and the Management of companies in industry. The Government is primarily involved through the Vocational Training Council, Industry Training Boards and educational institutions, but political representatives will also be involved. Complete identification of all the decision makers is a research project in itself.

The objectives of the decision makers are (1) to control the movement of technical people into, within, and out of the industry, and (2) to design new organisations so that industry adapts successfully to its environment. The Government's problem situation will be different from that of management in a particular company. The latter, however, will be included in the former. By appropriate resolution of the Government's situation each company's problem situation can be represented. It was assumed applied research would focus on the general problem.

For the Government to have deliberative control a model of its problem is required. This must include all the companies in the industry : an ecological model would probably be used. It will also include the environment of the industry; for example, overseas competition, the transportation system (domestic and international), and the energy system. Modelling each of these aspects will be a major research project.

The career structures of technically qualified people cannot be ignored either; this involves taking into account their goals and values in life. Consequently, attention must be directed to the whole of New Zealand society and its values. Other relevant factors could be discussed, but it should be clear by now how the problem is expanding outwards - generating further problems.(1)

Let us look instead at the kind of model management needs to control its technical staff. Initially one might assert that a model of each technically qualified person would be sufficient. This is not the case because (1) to determine the behaviors required from each person one must be able to differentiate between those which are relevant to the company's activities and those which are not - a model of the company as an individual is required; and (2) any system is more or less than the sum of its parts. A model of one person

(1) *Footnote: an initial attack on the Government's problem could be made using an approach suggested by Beer (1962).*

(A) may give another control over A while A acts alone, but it will not provide control when A acts in a group. A model of the company as a system is also needed.

Summarizing then, management requires three kinds of model to control their technical staff:

(1) a model of the company as an individual interacting with its environment,

(2) a model of the company as a system, each person being considered as an individual element in the company,

(3) a model of each person as a system.

These will be necessary for the design of new organisations as well.

At this stage, I believed a suitable management control model could be developed from Paterson's work (1969). His decision band theory classifies the kinds of decisions people make as members of an organisation. Paterson maintains five levels (bands) of decision exist in all organisations (horizontal differentiation). He also identifies the primary functions which he considers are necessary and sufficient for any organisation to survive (vertical differentiation). Members of an organisation are classified by their function and decision band.

Paterson primarily used his theory for grading jobs, but I could see no methodological difficulty in using it for manpower selection. The decision band theory can be used to classify each person in an organisation. The personality functions for successful behavior in each class can then be determined, as shown in Figure 2.1. Finally, a theory relating these personality functions to different types of organisations could be developed.

My intention was to formulate Paterson's model using the conceptual system of Ackoff and Emery (1972), develop a method of applying the model to determine the successful personality functions, and show where the model fits in the general problem situation previously outlined.

2.4 PROBLEM-ORIENTED RESEARCH AND THE TECHNICAL MANPOWER PROBLEM

Classification of the type of research necessary to investigate the technical manpower problem is important, because each of the three types - fundamental, applied and problem-oriented - requires a different approach by and a different orientation of the researcher. Hence, each would require a different content in the theoretical framework I intended to produce. To assist the reader in the following discussion I shall state my conclusion first: the technical manpower problem is generic and requires domain-based problem-oriented research for its inquiry.

The character of domain-based inquiry is described by Trist (1975):

If fundamental research is discipline-based, problem-oriented research may be said to be domain-based. Domain-based inquiry links a group of sciences to a major sector of social concern. The problems are generic rather than specific. They give rise to meta-problems. They require on-going endeavour leading to cumulations of findings rather than 'solutions'....Disciplines across the entire range of the physical, biological and social sciences tend to be drawn in. Their weighting and salience vary enormously between domains, which have very different centres and may evolve very different configurations.

Scientists, professionals, administrators and political representatives all become involved. The texture of their relationship differs from what it is in fundamental research, where scientific interest predominates, or applied research, where user-interest predominates. The relations of the different actors in a problem-oriented domain is that of collaboration....(p.91-92).

...There is accumulating evidence that field-determined, generic, problem-oriented research expresses the critical relation between science and society in the transition to post-industrialism....This is so also in developing countries making the transition from pre-industrialism to industrialism under the same turbulent conditions in which the advanced countries are concerned

with the transition to post-industrialism. A recent UNESCO survey has documented this theme as a world trend....(p.98).

...the domain of concern is with multi-organizational clusters rather than with single organizations; this has had the effect of directing attention both to the wider society and to the individual as a member of the social aggregate. (p.114).

The justification for my conclusion is:

(1) New Zealand is undergoing a transition from pre-industrialism to industrialism under what I consider to be turbulent conditions. Therefore, I expect domain-based research to express the critical relation between science and society.

(2) The expanding nature of the problem is typical of generic problems requiring domain-based inquiry i.e. they give rise to meta-problems.

(3) Government's concern is with the industry as a whole i.e. a multi-organisational cluster. This factor and concern with the career structures of technical personnel will direct attention *to the wider society and to the individual as a member of the social aggregate.*

(4) The broad range of decision makers concerned with the problem will mean that *scientists, professionals, administrators and political representatives all become involved.*

Trist (1975) points out that problem-oriented research requires collaboration defined at the programmatic rather than at the project level. Furthermore, he says:

The identification of themes for programmes cannot in the case of collaborative research be made in the abstract. These themes can be reached only by an analysis and realization of the nature and meaning of field experiences which carry social science engagement. (p.114-115).

With my limited resources it was apparent I would not be able to formulate the technical manpower problem nor define appropriate programme areas within which future research might be conducted. I decided, therefore, to concentrate on a specific project - the development of Paterson's model.

2.5 DECISION BAND THEORY : A CRITICAL ANALYSIS

The discussion which follows describes some of the limitations and inadequacies of Paterson's model. The conclusion is reached that his model should be discarded and the research project, as initially defined, abandoned.

Paterson's theory of organisations is based on an analogy with organisms. Ackoff and Emery (1972) stress that care should be taken with such analogies because the two systems are fundamentally different : the elements of the former are purposeful whereas those of the latter are not. For this reason I am not convinced that Paterson's set of primary functions is sufficient, although I believe it to be necessary. An additional function, dealing with morality or ethics, may be necessary for organisations to survive in certain types of environment. If Paterson's model was to be used, it was essential I determine which functions are necessary and sufficient for an organisation to survive : a project beyond my resources.

Paterson defines his decision bands in terms of the actions performed by people. This is acceptable provided the other components and parameters of the decision situations are clearly identified. Unfortunately, in his presentation these are implicit and I found it impossible to interpret his work objectively. Furthermore, he seems to consider jobs to be static, i.e. he assigns each person one unique set of decisions to make on behalf of the organisation. Jobs are arranged so that the majority of the decisions in each particular job are in the same band. This philosophy appeared to conflict with the work of Emery and Thorsrud (1975) regarding industrial democracy in Europe.

The turning point in my work was a fortuitous meeting with Professor Churchman. He pointed out the difficulties of reconciling Paterson's static model with the dynamic aspects of organisations. Professor Churchman also directed me to the work of Stafford Beer, for which I am extremely grateful.

Beer (1972) has produced an exceptionally penetrating cybernetic model of organisations. Although I only partially understood Beer's work at this stage, I recognised that his model was obviously superior to Paterson's model. Consequently, I decided to concentrate my efforts on Beer's work.(1)

The model proposed by Beer is at a very advanced level and I soon realized I would not be able to understand it sufficiently to develop it for my thesis. It was possible for me to use his work to produce a sub-model of some particular aspect of the technical manpower problem, but I declined to do so for two reasons:

(1) A frame of reference is required if the sub-model is to be related to other work being conducted on this problem. It was considered impractical to develop the necessary collaboration with other researchers to establish a frame of reference because of the delay involved.

(2) I could assume a frame of reference, but without collaboration with other researchers I may well duplicate research which had already been conducted. The practical value of my work would be correspondingly diminished.

The problem now confronting me was this: what work should I undertake for my thesis, given that I could not formulate the technical manpower problem nor define programme areas within which future research might be conducted, and would not produce a sub-model of some aspect of the problem?

(1) *Footnote: I now believe Paterson's work may be useful provided the user has a good understanding of Beer's work. I consider the former approach to be a crude, practical way of applying Beer's cybernetic model in certain situations.*

The solution to this seemingly insoluble problem is given in the next chapter.(1)

(1)
Footnote: At all stages I intended to conduct a survey for the EITB but this was never intended to be the major part of my thesis.

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THESIS 1

The technical manpower problem is : how do the New Zealand Government and management of companies in New Zealand industry control the movement of technically qualified people into, within, and out of the industry and design new organisations so that the companies and industry adapt successfully to their environments?

Inquiry of this problem requires domain-based problem-oriented research.

CHAPTER 3

THE RESEARCH PROJECT

3.1 INTRODUCTION

This chapter discusses modelling and identifies several variables considered to be essential for any model of technical manpower. The content of a scientific model of the Government's problem situation will depend on the orientation of the researcher, but all will contain variables and constants which must be defined if the models are to be meaningful.

It is concluded that developing idealized operational definitions of the variables mentioned above would be a suitable research project for this thesis, because they will provide scientific standards for all researchers regardless of their orientation.

3.2 MODELS

A lucid description of scientific models is given by Ackoff (1962, p.108-109):

Scientific models...are representations of states, objects, and events. They are idealized in the sense that they are less complicated than reality and hence easier to use for research purposes. These models are easier to manipulate and "carry about" than the real thing. The simplicity of models, compared with reality, lies in the fact that only the relevant properties of reality are represented....Scientific models are utilized to accumulate and relate the knowledge we have of different aspects of reality. They are used to reveal reality and - more than this - to serve as instruments for explaining the past and the present, and for predicting and controlling the future....

A scientific model is, in effect, one or a set of statements about reality.

An individual's model of his decision (choice) or problem situation is his representation of it. It consists of what he believes to be:

(1) The courses of action available to him.

(2) The possible outcomes of the available courses of action.

(3) The possible states of the choice environment (possible values of the uncontrolled variables that can affect the outcomes of available courses of action).

(4) The probability that each of the possible states of the choice environment is the true one.

(5) The efficiency of each available course of action for each possible outcome in each possible state of the choice environment.

(6) The relative value of each possible outcome.

In short, an individual's model of a choice situation must map, however inadequately, the components and parameters of the choice situation. [*Ackoff and Emery (1972, p.82)*].

A model of technical manpower, therefore, must map the components and parameters of the Government's problem situation.

The behaviors of technically qualified people will be essential elements of any model of technical staff. If these are to be represented in a symbolic model, which is the type science aims at producing, then they must be defined. I decided to define some of them for my thesis. To satisfy the requirement that my work be useful for various researchers, regardless of their orientation to the problem, idealized operational definitions would have to be developed. This type of definition is a scientific standard of a concept, which consists of:

...an explicit statement of the conditions under which, and the operations by which, questions concerning the concept ideally ought to be answered [*Ackoff and Emery (1972, p.7)*].

Developing idealized operational definitions of the behaviors of technical personnel satisfies the boundary conditions of the problem concluding the preceding chapter. The definitions will be useful as it is unlikely idealized definitions of those behaviors have already been developed. Even if they have my work will be useful, because it will provide another viewpoint.(1)

My colleague, Rod Jones, suggested I define an integrated set of behaviors. I selected planning, leading, organising, managing and designing. The first three are frequently cited as management functions. So also is controlling, but it was not included because it has been defined by Ackoff and Emery (1972, p.154). Designing was included because it is an important engineering activity and it is often confused with planning.

3.3 RESEARCH PROJECT DEFINITION

The aims of my research project, finally agreed on, were:

(1) To develop idealized operational definitions of designing, planning, leading, organising and managing using the rigorous conceptual system of Ackoff and Emery (1972).

(2) To conduct a survey for the New Zealand Engineering Industry Training Board.

(3) To investigate any areas of research highlighted by the survey, if time was available.

(1) *Footnote: this worked in well with the EITB survey. The aims of the survey had been specified at this stage, and one of them was to identify the tasks performed by engineers in industry - to do so required definitions of those tasks.*

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THESIS II

Domain-based inquiry of the technical manpower problem will aim to produce a symbolic model of the situation.

The following behaviors will be essential elements of this model: designing, planning, leading, organising, and managing. These must be defined if the model is to take on meaning.

The most useful definitions will be idealized operational definitions because they provide a scientific standard for all researchers, regardless of their orientation. Production of these definitions will be a suitable research project for a Ph.D. Thesis.

CHAPTER 4

DEFINING

4.1 INTRODUCTION

The importance of defining cannot be overemphasized. Ackoff (1962, p.174) notes:

Defining is an aspect of the research process which all too few scientists take very seriously. The meanings of the concepts are too often taken for granted. Yet definitions are essential as criteria for relevance of data used in evaluating variables and constants in all types of scientific statements : theories, laws, facts, and decision models.

Furthermore, he points out:

The progress of science, pure and applied, is as dependent on progress in defining as on progress in any other aspect of inquiry (p.175).

Our main concern is the relevance of defining to models because it is intended that the definitions produced in this thesis be used in technical manpower models. The type of models we are considering are symbolic ones. The relevance of defining to these is succinctly stated by Ackoff (p.141):

The symbols in a symbolic model represent variables, constants, and the relationship between them. In its symbolic form the model represents only the structure of the problem and the phenoma involved. The model takes on meaning or content only when the symbols and the things which they represent are defined.

There are two types of defining in science : conceptual and operational.

Conceptual defining is sometimes called constitutive...This type of definition relates the concept being defined to one or more other concepts and generally takes a form similar to that of dictionary definitions. Operational definitions, on the other hand, relate a concept to what would be observed if certain operations are performed under specified conditions on specified objects (Ackoff, p.141).

4.2 OPERATIONAL DEFINING

The aim of operational defining is to specify a set of operations by which questions regarding a concept can be answered. The set of operations and the conditions under which they are to be performed should be ideal ones i.e. those which cannot be practically carried out and met. The reason for idealized operational defining is clearly explained by Ackoff (1962, p.152): *... specification of ideal (or optimal) observational conditions and procedures is quite important if we want to know how good are the results we eventually obtain. Further, and more important, the ideal conditions and procedures act as a standard by means of which we can compare observations made under different conditions using different operations by making adjustments in the results so that they represent what would have been obtained under the standard conditions.*

The variables and constants which appear in a model represent objects, events or properties of these. Objects and events are defined in terms of their essential properties, therefore all operational definitions should be definitions of properties.

Properties can be classified into two types: structural or functional. A structural property is any geometric, kinematic, mechanical, physical, or morphological property e.g. the temperature of an object. Structural properties are essentially deterministic.

Functional properties refer to:

...the origin or use to which objects can be put or put themselves (Ackoff, p.175).

These properties are essentially probabilistic i.e. measures of functional properties are measures of probability. An example of a functional property is the degree of aggressiveness of an individual.

4.3 CONTENT OF DEFINITIONS

A procedure for defining is given by Ackoff (p.150) as follows:

(1) Examine as many definitions of the concept, past and present, as possible. Keep in mind the chronology of the definitions examined.
(2) Try to identify the core of meaning toward which the definitions seem to be evolving.
(3) Formulate a tentative definition based on this core.
(4) Examine usage of the concept in the context of the problem or question to which the research is directed and determine if the meaning you have formulated will serve the decision makers' or research objectives. If not, make necessary revisions.
(5) Submit the definition to as wide a critical appraisal as possible and make any justifiable revisions suggested by the criticism.

The above procedure, except for item (5), was followed in formulating the definitions given in Chapters 5-9. Item (5) was excluded because it was considered incompatible with the intention of obtaining a Ph.D. degree.

Item (4) caused considerable concern because the definitions are intended to assist various researchers, in different problem situations, develop models of technical personnel. Current usage of a particular concept

was examined across a range of relevant disciplines and a definition was formulated which seemed most appropriate for that range. Quite clearly I cannot hope to have resolved all the ambiguities and meanings attributed to the concepts involved. I believe, however, I have provided a basis for constructive discussion.

A detailed procedure was developed from the first three stages of Ackoff's method. This procedure is described below:

(1) Look for library references using the subject catalogue. Jot down all references specified under the appropriate subject heading.

(2) Choose one or two books of selected readings from the reference list, and read each book completely. This provides an initial orientation to the concept. These books are chosen initially because they contain several viewpoints. At this stage, also, the Oxford English Dictionary definition is obtained.

(3) Rearrange the list in (1) into a set of bibliographical groups. Each group consists of a set of book references which are located near each other in the library system. Conduct the literature survey according to the groups. This is the fastest way of working through the list and it enables one to find other relevant works not on the list, but in the same bibliographical groups as the listed references.

Clearly, not every book can be read completely; however, those works which are considered to be authoritative on the subject should be read completely. For the other works, read as much as is necessary to interpret each author's definition.

(4) Record each author's name, the date of his work, the library reference, his definition and other key points relating to the concept. If one author includes another's definition in his work copy this down also. There may not be time to read the work of the latter author or his work may not be available.

When the survey of listed works is completed the search can be extended to include works referenced by the authors previously surveyed.

(5) Edit the definitions and identify the core of meaning of the concept.

(6) Use the most recent definitions to identify the essential properties of the concept.

(7) Use (5) and (6) to formulate a definition of the concept.

4.4 PRESENTATION OF DEFINITIONS

The format for the next five chapters (excluding Chapter 8) is:

(1) Introduction.

(2) Historical analysis (mainly based on the Oxford English Dictionary):

(a) presentation and discussion of a sample of definitions.

(b) identification of the core of meaning of the concept.

(3) Identification of the essential properties of the concept.

(4) Presentation and discussion of the definition.

(5) Analysis of the concept in detail, where this has been carried out.

The number of references has been reduced by selecting a sample of the definitions for discussion. For each concept, the literature surveyed is presented in a separate appendix (Appendices 1 - 5) in the following manner:

(1) the works from which the sample definitions have been taken are fully referenced;

(2) the remainder are indicated by an alphabetical list of the authors.

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CHAPTER 5

DESIGNING

5.1 INTRODUCTION

Designing is regarded by most professional engineers as the activity which distinguishes the professional engineer from the non-engineer. It is recognised as an important engineering activity by the engineering professional institutions. Consequently, considerable research effort has been directed at improving design techniques, training engineers to design, and developing design aids for the designer. Yet despite this work no adequate definition of designing has been formulated.

Current usage of designing is inconsistent; frequently it is confused with planning. The reason for this confusion becomes apparent after a study of Figure 5.1, which is a summary of the Oxford English Dictionary definition of design. The meaning of design ranges from *intending something* to *making a sketch or drawing of something.* There is considerable overlap between this definition and the definition of plan given in Figure 6.1 (p.41).

Two alternatives are available to resolve this difficulty:

(1) Plan and design can be considered as two different words which have the same meaning. One should therefore be deleted.

(2) They can be considered to have different meanings; therefore definitions should be developed which clearly point out the differences.

I have selected the second alternative.

5.2 HISTORICAL ANALYSIS OF DESIGN

Our search for the meaning of design begins in the 14th century, during which design was used as a verb. It had the meaning *to mark or point out, to nominate, to appoint.*

During the 15th and 16th centuries the concept was extended and the use of design as a substantive appeared. The verb design retained its 14th century meaning, but also included the following ideas:

(1) to purpose, to intend anything,

(2) to devote intentionally,

(3) to plan, to project, to form an idea.

The substantive design meant:

(1) an intention, a purpose,

(2) a scheme formed to the detriment of another,

(3) a scheme, a plan of action,

(4) the idea which an artist endeavours to execute or express.

The ideas introduced in the 15th and 16th centuries have continued to be revised and extended. The original meaning of design, however, has become obsolete.

A modern conception of design is provided by Ackoff (1955, p.5): *To design is to plan; that is, design is the process of making decisions before the situation arises in which the decision has to be carried out. It is a process of deliberate anticipation directed toward bringing an expected situation under control.*

Asimow (1962, p.1) relates design to the fulfilment of human needs: *Engineering design is a purposeful activity directed toward the goal of fulfilling human needs, particularly those which can be met by the technological factors of our culture.*

He also notes:

A designer does not usually produce the goods or services which immediately satisfy a consumer's needs. Rather, he produces the model which is used as a template for replicating the particular good or service as many times as is required (p.1).

The idea that designing produces a 'model' is emphasized by Alexander (1970, p.15):

The ultimate object of design is form....every design problem begins with an effort to achieve fitness between two entities : the form in question and its context. The form is the solution to the problem; the context defines the problem.

He defines the design process as:

...the process of inventing physical things which display new physical order, organization, form, in response to function (p.1).

Matousek (1963, p.4) observes:

The designer uses his intellectual ability to apply scientific knowledge to the task of creating the drawings which enable an engineering product to be made in a way that not only meets the stipulated conditions but also permits manufacture by the most economic method.

He distinguishes between designing and planning:

Nor can planning be used as an alternative term for design. Planning is rather the preparation of schemes for the use of land, buildings, and industrial equipment (p.3).

A cybernetic view of designing is provided by Ashby (1971, p.253):

Thus the act of "designing" or "making" a machine is essentially an act of communication from Maker to Made, and the principles of communication theory apply to it. In particular the measures that were developed for treating

the case in which various possible messages are reduced to one message can now be applied to the case when various possible machines are reduced to one machine.

This definition is objective as Ashby notes:

Thus the idea of one machine designing another can be stated in exact and general terms - exact in the sense that experiment can be used to show objectively whether or not this relationship holds (p.255).

The artistic view of design is illustrated by the following definition from the Dictionary of Arts and Crafts:

design : This is a sketch or layout for a drawing or illustration, or for the construction of some object. In art, a design is sometimes the interpretation of an artist of some object or scene.

Churchman (1971) has identified the following characteristics of design:

(1) It attempts to distinguish in thought between different sets of behavior patterns.

(2) It tries to estimate in thought how well each alternative set of behavior patterns will serve a specified set of goals.

(3) Its aim is to communicate its thoughts to other minds in such a manner that they can convert the thoughts into corresponding actions which in fact serve the goals in the same manner as the design said they would.... (p.5)...There is a fourth characteristic of design behavior...This is the goal of generality, or, as many would put it, methodology; the designer strives to avoid the necessity of repeating the thought process when faced with a similar goal-attainment problem by delineating the steps in the process of producing a design....(p.5)...To the four characteristics of design given above, we must therefore add a fifth which is specific to the

design of systems: the systems designer attempts to identify the whole relevant system and its components; the design alternatives are defined in terms of the design of the components and their interrelationships. (p.8).

Throughout all the definitions I believe the core of meaning of design is *to point out the essential features of.* In the 14th century design meant to point out the essential features of existing objects. Over the centuries, that which is connoted by a design has changed from existing objects to non-existent objects and future actions.

5.3 ESSENTIAL PROPERTIES OF DESIGN

All definitions of design imply the design process is performed by psychological individuals. However, there is no reason why it cannot also be performed by social groups or purposeful machines, as Pask (1963, p.153) observes:

...a designer...may be a man, or a group of men, or a mechanism, without restriction.

One essential property of designing is that it is produced by a purposeful system.

The product of designing is a message connoting the essential features of something. This point is illustrated by the following statements:

A designer makes and manipulates shapes in his environment. To do so, he must conceive and construct these shapes....The shape itself is any visual or semantic or auditory or tactile form, recognizable as a sign in a given universe of discourse. [Pask (1963, p.153)].

...a design is a description of an object and a prescription for its production; therefore, it will have existence to the extent that it is expressed in

the available modes of communication. [Asimow (1962, p.6)]

...the definition of design is seen to embrace the process of applying principles and techniques for the purpose of defining a device in sufficient detail to permit its realisation. [Jones (1973, p.2)].

The last two statements also indicate the 'something', which has its features delineated, is an object which does not exist when the design is produced. The product of designing is a message connoting the essential properties of an object which does not exist when the design is produced.

Two other characteristics are necessary to define designing. Churchman has made the comment that designing involves thinking; Asimow has noted it fulfills a need. The idea of need fulfilment indicates the designer has a *client* whose needs are to be fulfilled. The designer, it seems, starts with a brief from his client i.e. he is told something about the object he is to design.

Thinking implies the designer 'creates' in his own mind some of the properties he specifies in the design. For him to 'create' these properties in his mind two conditions must be satisfied:

(1) he must not be aware of the complete set of properties in the design when he starts designing; and

(2) he must not perceive a set of properties in his environment while he is designing, such that this set and those properties he starts with (given in his brief) make up the complete set given in the design.

5.4 DEFINITION OF DESIGNING

A purposeful individual (A) designs, if in a choice environment S in a time-period $t_1 - t_2$:

(1) A produces a message M_1 connoting two or more essential properties $\{p_x\}$ of a concrete system(s) or object(s), which does not exist in any environment at time t_1;

(2) the message (M_1) is a potential producer of at least one essential structural property of the system(s) or object(s) in some environment S_j;

(3) at time t_1, A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ in S such that the union of $\{p_1\}$ and $\{p_s\}$ exhausts $\{p_x\}$.

The set of properties $\{p_x\}$ is the design.

There are several points which should be noted:

(1) Statement (2) recognises the commonsense usage of design where, if a person believes a 'design' cannot be used to produce an object in <u>any</u> environment, then he would not call it a design.

(2) I consider the set of properties $\{p_x\}$ to be the 'design', rather than the message. Translation of a design from one language to another produces a different message but does not change $\{p_x\}$; hence, the same object is connoted.

(3) The design may be a mental message, as in the case of a surrealistic painter or graphic artist; or it may be formed in the designer's environment, for example an engineering drawing.

(4) The design process may be a choice or problem-solving process.

5.5 ANALYSIS OF THE DESIGN PROCESS

A designer starts with a set of properties $\{p_1\}$ and produces a set $\{p_x\}$. If these sets could be classified in a meaningful way a useful classification of design situations will have been produced. I intend, now, to develop such a classification.

The minimum amount of information the designer may start with is a statement of the user's need i.e. a description and/or explanation of his choice or problem situation (the user is the individual who will actually use the designed object once it has been produced. The user and the client may not be the same individual). The user's desired outcome (end, goal, objective or ideal) can be called the *general function* of the system to be designed (Refer to Figure 5.2).

The user will, in general, have more than one course of action available to him. An instrument used in one course of action can be expected to perform a different function in that course of action compared to a different instrument used in another course of action. Yet the set of all the instruments' functions in the available courses of action has the function of producing the user's desired outcome. I have called the function of an instrument in a course of action its *specific function* or *performance specification.*

I am grateful to my colleague Rod Jones for the following example, which will illustrate these two functional levels:
A mining company wishes to move x tonnes of coal per day from its coal-mining plant to its steel-making plant. The distance between the two plants is 100 km. The designer is asked to design a material handling system for this purpose.

Two possible alternatives for transporting the coal are conveyors and trucks. It is obvious the performance specification of a truck will be completely different from the performance specification of a conveyor; yet both of these systems produce the company's desired outcome - x tonnes of coal moved per day.

Given the performance specification of a system its structure must next be defined. I have identified two levels of structural classification, which are probably sufficient for most purposes. (There is no methodological difficulty to adding more levels if required).

The *general structural* classification identifies the different morphological classes of systems which are potential or actual producers of the actions and outcomes given in the performance specification. The *specific structural* class is a description of the system sufficient for it to be manufactured in some environment.

The initial set of properties, $\{p_1\}$, the designer is aware of can belong to classes 1 , 2 , or 3 , (see Figure 5.2). By definition a design of class 4 is sufficient for the system to be made, hence no further design is required.

The final set of properties, $\{p_x\}$, can belong to classes 2 , 3 , or 4 . This follows from the definition of class 1 ; it is the minimum information about the system which the designer can receive.

The four classes can be defined more precisely. If $\{p_i\}$ is the set of essential properties of an image(s) and $\{p_f\}$ is the set of essential properties of a concept(s) connoted by a message then:

$$\text{if } \frac{\{p_i\}}{\{p_f\}} > 1.0 \text{ the message is } \textit{structural},$$

$$\text{if } \frac{\{p_i\}}{\{p_f\}} < 1.0 \text{ the message is } \textit{functional}.$$

In other words, structural designs mainly describe and functional designs mainly explain.

According to this classification, designs of classes 4 and 3 will be structural. Functional designs are those of classes 1 and 2 .

Given the above restrictions for $\{p_1\}$ and $\{p_x\}$, and the further constraint that a message connoting properties of any class must also connote properties of a higher class - i.e. a message connoting properties of class 3 must also include properties of classes 1 and 2 - an exclusive and exhaustive set of design situations can be produced. This is shown in Figure 5.3.

The performance specification of a system will depend on its functional type. Using the scheme of Ackoff and Emery (1972, p.29), I will now identify the actions and outcomes necessary and sufficient to define the performance specification of each type of system.

(1) Passive Functional Systems

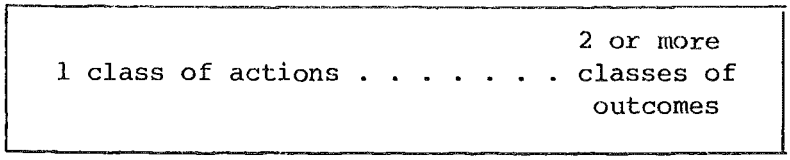
The performance specification of these systems requires definition of one functional class of outcomes and one structural class of actions in all environments.

1 class of actions . . . . . 1 class of outcomes

Diagrammatic Representation of Performance Specification

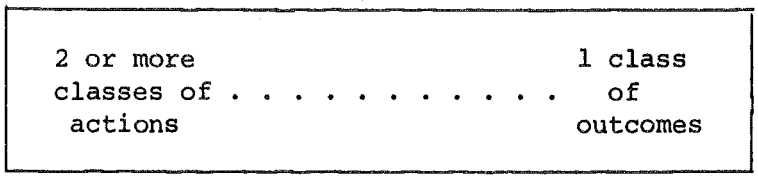
(2) Passive Multi-Functional Systems

Requires specification of one functional class of outcomes in any environment, different functions in different environments, and one structural class of actions in all environments.



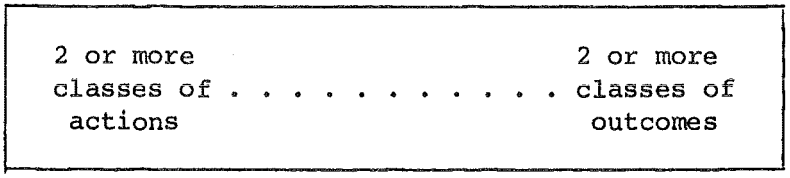
(3) Reactive Functional Systems

Same as for 1. except different classes of actions in different environments must be included.



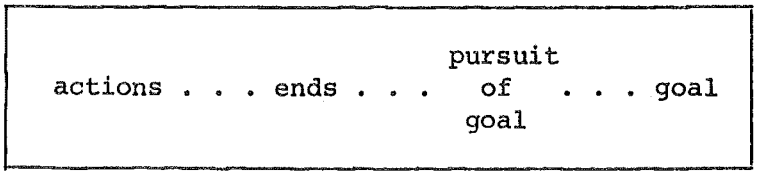
(4) Reactive Multi-Functional Systems

Same as for 3 except different functions in different environments must be specified as well.



(5) Goal-Seeking Systems

These systems seek one goal in all environments and can perform different structural classes of actions in the same or different environments. The specification must include all of 3 above, the goal, and how to pursue the goal.



(6) Multi-Goal-Seeking Systems

These systems are the same as goal-seeking systems except they can seek different goals in different environments - these must be specified.

actions . . . ends . . . pursuit of goals . . . 2 or more goals

(7) Purposeful Systems

There are two types of these systems: objective-seeking and ideal-seeking.

(a) Objective-Seeking Purposeful Systems

The objective(s) and how to pursue the objective(s) must be given as well as all of 6 above.

actions . . . ends . . . pursuit of goals . . . goals . . . pursuit of objectives . . . objectives

(b) Ideal-Seeking Purposeful Systems

Specification contains all of 7(a) and also includes ideals and how to pursue these.

actions - ends - pursuit of goals - goals - pursuit of objectives - objectives - pursuit of ideals - ideals

A designer may receive as $\{p_1\}$ any of the items shown in the performance specifications above, and produce any of those items as $\{p_x\}$, provided $\{p_1\}$ and $\{p_x\}$ are ordered from right to left.[1] Herein lies the source of

[1] *Footnote: The message a designer receives or produces must contain all items to the right of the item considered as well as that item itself. The former may be explicit or implicit.*

confusion between designing and planning. A plan may also contain some of the items shown in the diagrams for the design performance specification of goal-seeking and purposeful systems (Refer to Chapter 5, p.49).

The two activities can be differentiated in these instances only by referring to the system connoted by the set of properties $\{p_x\}$. If the system exists at time t_1, the activity is planning; if it does not, the activity is designing.

One may well ask whether this difference is significant: I believe it is. The planner has his problem constrained because the structure of the system being planned for is fixed. The designer is not so constrained, therefore the variety of a designing situation will be considerably larger than the variety of a planning situation. Consequently, a designer is a greater variety reducer than a planner. I consider designing to require more intellectual ability than planning for this reason.(1)

I believe future research into the design process is most fruitfully conducted along the lines suggested by Churchman (1971). He points out the importance of other minds to the designer : these are the *client* and the *decision-maker* (the person who receives the design). Investigation of the communication processes between client and designer, and designer and decision-maker, could determine the conditions necessary for successful production and implementation of a design.

My work fits neatly within this schema. I have classified the messages a designer receives and produces : these are essential elements of the communication processes mentioned above.

(1) *Footnote: This comment will only apply when comparing designing and planning of systems at the same functional level.*

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THESIS III

A purposeful individual (A) designs, if in a choice environment S in a time-period $t_1 - t_2$:

(1) A produces a message M_1 connoting two or more essential properties $\{p_x\}$ of a concrete system(s) or object(s), which does not exist in any environment at time t_1;

(2) the message (M_1) is a potential producer of at least one essential structural property of the system(s) or object(s) in some environment S_j;

(3) at time t_1, A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ in S such that the union of $\{p_1\}$ and $\{p_s\}$ exhausts $\{p_x\}$.

The set of properties $\{p_x\}$ is the design.

CHAPTER 6

PLANNING

6.1 INTRODUCTION

Planning is an activity which is carried out daily by most people. We plan when we believe the consequences of doing nothing, in a particular situation, will be undesirable. Planning is thus an essential aspect of our personal affairs, of business activities, of communal and Governmental administration.

Concern with improving the planning process for business and Governmental administration has resulted in a considerable body of literature on planning. Many definitions of planning have been proposed, but most are of little value because of their broad context. Planning is also frequently confused with other activities, such as forecasting, as Schumacher (1974) notes:

Endless confusion results from the semantic muddle in which we find ourselves today. As mentioned before, 'plans' are put forward which upon inspection turn out to relate to events totally outside the control of the planner. 'Forecasts' are offered which upon inspection turn out to be conditional sentences, in other words, exploratory calculations. The latter are misinterpreted as if they were forecasts or predictions. 'Estimates' are put forward which upon inspection turn out to be plans. And so on and so forth. (p.190).

In this chapter I attempt to sort out this confusion. To provide the reader with an initial orientation to the concept of planning a summary of the Oxford English Dictionary definition of *plan* is shown in Figure 6.1.

I believe the concepts of planning as *to make a plan of something existing* and *to make a plan of something to be constructed* are best included in modelling and designing respectively. I shall concentrate on the idea of a plan being *a predetermined course of action.*

6.2 HISTORICAL ANALYSIS OF PLANNING

The English use of the substantive plan, in the 17th and 18th centuries, was a combination of the French and Latin usage. Plan had two meanings:

(1) a scheme; a form; a model (of action),

(2) a plot of any building or ichnography; form of any thing laid down on paper.

The verb plan meant:

(1) to make a plan of something existing,

(2) to make a plan of something to be constructed,

(3) to scheme.

All these meanings have survived to the present day. Some modern definitions of planning are given below.

Scott (1972, p.41) provides this definition of planning:
Planning is an analytical process which encompasses an assessment of the future, the determination of desired objectives in the context of that future, the development of alternative courses of action to achieve such objectives, and the selection of a course of action or courses of action from among these alternatives.

Steiner and Drucker stress that planning is not making future decisions but current decisions in the light of their futurity:

Planning is not making future decisions. Planning is concerned with making current decisions in the light of their futurity....The basic problem of planning is not what should be done in the future but rather what should be done now to make desired things happen in the uncertain future. [Steiner (1969, p.18)].

...strategic planning...is the continuous process of making present entrepreneurial (risk-taking) decisions systematically and with the greatest knowledge of their futurity; organizing systematically the efforts needed to carry out these decisions; and measuring the results of these decisions against the expectations through organized, systematic feedback. [Drucker (1959, p.125)].

Ackoff, on the other hand, takes an opposing point of view:

...planning is anticipatory decision making: it requires a time lapse between making decisions and carrying them out. (1972, p.55).

He defines planning as follows:

Planning is anticipatory decision making. The decisions involved in it form a system of interdependent parts. Because this system is too large and complex to handle all at once, planning must be done in parts, and each part must be evaluated and re-evaluated in light of at least one other part. The system being planned for is part of a dynamic environment which is such that organizational performance is likely to deteriorate unless management intervenes in the processes going on inside and outside the organization (p.56).

Murdick gives a detailed definition of planning:

Planning is a conscious intellectual process characterized by (a) identification of a need or reflection of a stimulus, (b) accumulation of information, (c) relating of bits of information and beliefs, (d) establishing objectives, (e) establishing premises, (f) forecasting future conditions, (g) structuring

alternative chains of actions based upon sequential decisions, (h) ranking or selecting total plans which will achieve the best balance of ultimate objective and subsidiary objectives, (i) establishing policies, and (j) establishing standards and means for measurement of adherence to the plan of action. (1971, p.41).

Argenti (1974, p.13) says:

A better way to define planning is to describe it as the process that leads to a plan. A plan is a set of instructions to someone and the planning process ends when these are ready to be issued.

I believe Ackoff has identified the core of meaning of planning when he states *planning is anticipatory decision making.* This meaning was certainly captured in the definition of plan in the 17th and 18th centuries. It is contained in most modern definitions as well.

6.3 ESSENTIAL PROPERTIES OF PLANNING

All definitions of planning assume the planner is a psychological individual, but few comments are made about social individuals or purposeful machines being planners. I believe the latter can be planners; hence, the producer of plans is a purposeful system.

A way of distinguishing between planning, estimating, forecasting, and budgeting is given by Schumacher (1974, p.188-189):
We talk happily about estimating, planning, forecasting, budgeting, about surveys, programmes, targets, and so forth, and we tend to use these terms as if they were freely interchangeable and as if everybody would automatically know what was meant...The terms we use may refer to the past or to the future; they may refer to acts or to events; and they may signify certainty or

uncertainty. The number of combinations possible...is...8...The eight possible cases may therefore be ordered as follows:

1. *Act*
   Past
   Certain
2. *Act*
   Future
   Certain
3. *Act*
   Past
   Uncertain
4. *Act*
   Future
   Uncertain
5. *Event*
   Past
   Certain
6. *Event*
   Future
   Certain
7. *Event*
   Past
   Uncertain
8. *Event*
   Future
   Uncertain

My interpretation of Schumacher is that he considered planning to apply to cases 2 and 4. Their common feature is they both refer to future acts.

The definitions of planning indicate there is a choice of actions available to the system being planned for in its expected environment. The system being planned for must, therefore, be at least at the goal-seeking level. Can we plan for a goal-seeking system? If we are referring to a social individual which is goal-seeking then the answer is yes. If we are referring to a machine which is goal-seeking i.e. a computer the answer may well be no. Yet we use the word programming for both computer systems and social systems.

I consider a computer program to be a type of plan, therefore computers will be included in my definition of planning. The system being planned for is a goal-seeking or purposeful system.

Planning is oriented toward a desired outcome. The plan must specify a choice, if the system is goal-seeking; or a course of action, if the system is purposeful. This is different from just specifying the action of a system. The former indicate the action is directed at an outcome i.e. has a function.

In the previous chapter we noted one difference between designing and planning. That is, a design connotes a non-existent system when it is produced; a plan connotes or denotes an existing system when it is produced. There is another major difference between planning and designing: this is the amount of information the designer or planner may start with.

A designer may start with the client's or user's choice situation. Can the same be said for the planner? The answer is NO! Ackoff (1970) makes this quite clear:

...planning must begin with a reference projection and a wishful projection. It cannot terminate until it has produced a planning projection....(p.23).

...Planning is based on (a) a reference projection - a prediction of what is likely to come about if there is no planned intervention; and (b) a wishful projection - an expression of where the company would like to be at the end of the planning period. The objective of planning is to produce a planning projection which specifies how far the planners believe the organization can go toward fulfilling its wishes, (p.40).

Production of the reference projection involves forecasting and the making of conditional statements. Forecasting deals with predicting events outside the planner's control. A conditional statement is a statement of

how the system being planned for will behave in the forecast conditions if there is no planned intervention.

The wishful projection may be an end, goal, objective or ideal of the system being planned for. Ackoff does not include ends in his definition of planning; he deals with a set of interrelated decisions. Planning for an end is a trivial and limiting case, but I believe it should be included in the definition.

Finally, we can note the planner must 'create' in his own mind some of the properties of the course of action. He must not be aware of the complete set of properties defining the course of action when he starts planning; and he must not perceive all of them from his environment while he is planning.

The essential properties of planning can be summarized as follows:

(1) The producer of planning is a purposeful system.

(2) The product of planning is a plan, which connotes the essential properties of a future course of action (choice) of a purposeful system (goal-seeking system).

(3) The planner must not be aware of the complete set of properties in the plan when he starts planning.

(4) The planner must not perceive in his environment a set of properties such that these and the set he starts with make up the complete set given in the plan.

(5) The minimal information a planner can start with is a reference projection and a wishful projection.

6.4 DEFINITION OF PLANNING

Two preparatory definitions are necessary.

wishful projection: A message connoting an end(s), goal(s), objective(s), or ideal(s), or some combination of these.

reference projection: A message connoting an expected environment of a purposeful (goal-seeking) system and the course(s) of action (choice(s)) of the system in that environment when the system does not expect it.

A purposeful individual (A) plans, if in a choice environment S in time-period $t_1 - t_2$:

(1) A produces a message M_1 connoting two or more essential properties $\{p_x\}$ of an available course(s) of action (choice(s)) of another individual (goal-seeking system) C, that exists at time t_1, in a choice environment S_j at t_j for C to produce an outcome O_k at t_k ($t_k > t_j > t_2$);

(2) the message (M_1) is a potential producer of O_k;

(3) at time t_1, A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) the sub-set $\{p_1\}$ must include the essential properties of a wishful projection and a reference projection for C;

(5) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ in S such that the union of $\{p_1\}$ and $\{p_s\}$ exhausts $\{p_x\}$.

The set of properties $\{p_x\}$ is the plan.

Several points can be noted:

(1) A and C may be the same individual.

(2) The plan may be a mental message or formed in the environment.

(3) Time is an essential aspect of any plan, but it is important to recognize that timing of a plan or parts of a plan can occur in two different ways.

First, the plan or its parts can be timed according to our standard time system i.e. in terms of minutes, days, months etc.

Second, the plan or its parts may be timed in terms of some other time system i.e. based on events other than those which define our standard time system. Hence, it is possible for parts of a plan to be timed according to completely different time systems. There is nothing wrong with this provided the people using the plan can recognize the time in the different systems.

A plan, whose parts are timed according to different time systems, may be transformed to one which has the times in one time system by *scheduling*.

(4) Some time systems are cyclical in nature, hence it is possible for a plan to be used more than once. This is called a repeat use or standing plan. For it to be useful not only must the time system be cyclical but the reference and wishful projections must be the same on each occasion.

Planning situations could be classified as follows (analogous to the classification developed for designing):

morphologically
or structurally ← ends ← goals ← objectives ← ideals
defined action

I consider it more fruitful to classify planning according to:

(1) the expected environment,

(2) the portion of the social individual being planned for (if applicable),

(3) the time-period ahead being planned for,

(4) the ends-means orientation of the plan.

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THESIS IV

wishful projection: a message connoting an end(s), goal(s), objective(s) or ideal(s), or some combination of these.

reference projection: a message connoting an expected environment of a purposeful (or goal-seeking) system and the course(s) of action (choice(s)) of the system in that environment when the system does not expect it.

A purposeful individual (A) plans, if in a choice environment S in a time-period $t_1 - t_2$:

(1) A produces a message M_1 connoting two or more essential properties $\{p_x\}$ of an available course(s) of action (choice(s)) of another individual (goal-seeking system) C, that exists at time t_1, in a choice environment S_j at t_j for C to produce an outcome O_k at t_k ($t_k > t_j > t_2$);

(2) the message (M_1) is a potential producer of O_k;

(3) at time t_1, A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) the sub-set $\{p_1\}$ must include the essential properties of a wishful projection and a reference projection for C;

(5) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ in S such that the union of $\{p_1\}$ and $\{p_s\}$ exhausts $\{p_x\}$.

The set of properties $\{p_x\}$ is the plan.

CHAPTER 7

LEADERSHIP

7.1 INTRODUCTION

There have been many approaches to the study of leadership, each representing a different orientation of the investigator. Few researchers have acknowledged the benefits to be gained from considering approaches other than their own and fewer still have tried to synthesize the various viewpoints into an integrated scheme. Yet each viewpoint is valid to a certain degree, therefore a definition of leadership should encompass them all.

The main approaches are : great man, trait, situational, group function, followership, leadership values and symbolic leader.

(1) Great Man Approach

This approach is based on the supposition that the qualities which make a leader successful are inborn and cannot be analysed. It is not very useful.

(2) Trait Approach

Arising out of the great man approach is the trait approach. It is still assumed successful leadership depends on the characteristics of the leader but it is now supposed these can be identified.

Initially, physical characteristics were studied but no common physical attributes were identified among successful leaders.

Next, lists of personality traits were drawn up and attempts were made to correlate these with successful leadership. The early efforts were not

successful because the techniques were crude and unreliable, and the lists of traits reflected the characteristics researchers believed leaders should have rather than what they were actually like.

Modern trait research has overcome most of the difficulties but it is still criticised as being insufficient to explain leadership behavior. The major criticism is the results of trait research depend largely on the method of identifying the leaders.

Disillusionment with the trait approach led some researchers to conceive of leadership as a property of a group rather than of an individual. Two separate schools of thought derived from this viewpoint : situational approach and group function approach.

(3) Situational Approach

It is assumed leadership is spread throughout a group of people and the leader is the person who has the most influence on the group's activities. Leadership is seen as a function of the characteristics of the leader, the followers and the situation.

To select a leader for a given group of people, research is conducted to find the person who will emerge as leader in the group. He is formally appointed leader of the group.

Objections to this approach are based on the fact that (a) it ignores similarities between various groups and situations, and (b) an emergent leader may not be the best leader when formally appointed leader, because of the change in relationships produced by the appointment.

(4) Group Function Approach

Whereas the situational approach looks for differences between groups and situations this approach looks for similarities. It is assumed all

groups require certain leadership functions to be performed. The leader is the person seen by members of the group as most capable of fulfilling all or some of those functions. Again, leadership is thought to be spread throughout the group.

Objections to this approach are it ignores differences between groups and oversimplifies the actual situation.

(5) Followership Approach

This is really a modification of the trait approach. Leadership is thought to depend on the followers. The characteristics of the followers are studied to determine those necessary for successful leadership.

(6) Leadership Values Approach

Recent efforts have concentrated on looking at the leader and his followers as members of a larger social system e.g. a society. The emphasis is on the values of the leader and his followers and their relationships to the social system.

(7) Symbolic Leader Approach

A completely different approach is to concentrate on leaders as symbols. Leadership is explained in terms of "public drama". The leader is seen as an actor playing a role to the mass public, his audience.

Klapp (1964) provides this description of the symbolic leader:

Certain persons have enormous effect, not because of achievement or vocation but because they stand for certain things; they play dramatic roles highly satisfying to their audiences; they are used psychologically and stir up followings. (p.32).

Summarizing, a definition of leadership should include the following:

(1) the characteristics of the leader,

(2) the characteristics of the followers,

(3) the characteristics of the group,

(4) the characteristics of the situation,

(5) the values of the leader and his followers and their relation to the larger social system,

(6) symbolic leadership - the idea of a leader acting in a public drama.

7.2 HISTORICAL ANALYSIS OF LEADERSHIP

The Oxford English Dictionary defines leadership as *the ability to lead.* The meaning of leadership is to be found in the meaning of the verb *lead,* an historical analysis of which is presented below.

According to the Oxford English Dictionary the first recorded use of lead was 825 AD. It had the meaning *to bring or take a person or animal to a place.* The leader was a person or supernatural being. This particular usage of the concept is now obsolete.

The concept was extended during 900 - 1100 AD to include leading of flexible inanimate things, to differentiate between ways of leading, and to include leading a group of people. The additional meanings are illustrated below, in chronological order:

(1) to carry or convey, usually in a cart or other vehicle (900 AD);

(2) with regard to a commander, it means marching at the head of and directing the movement of a group of people (900 AD);

(3) to go before or alongside and guide by direct or indirect contact (971 AD);

(4) to guide the course or direction of something flexible e.g. rope (1050 AD).

During the next four centuries the meaning of lead was considerably modified. The list of things which could lead was extended (to include inanimate objects, motives, conditions and circumstances being able to lead), the list of things which could be led was extended, the situations within which leading could occur were further enumerated, and the idea of being first or foremost was introduced. Some examples of these meanings are:

(1) of a way, road, etc. : to serve as a passage for, conduct a person to or into a place (1200 AD):

(2) of motives, conditions, circumstances : to guide, direct to a place (1300 AD);

(3) to have the first place in; to march in the front line of (1380 AD);

(4) of a clue, light, sound : to serve as an indication of the way (1697 AD).

Let us now consider some modern definitions of *leadership*. For Koontz and O'Donnell (1972) leadership is:

...the art of inducing subordinates to accomplish their assignments with zeal and confidence (p.557).

Fiedler (1969, p.231) states that:

...leadership is essentially a relationship in which one person uses his power and influence in getting a number of people to work together and accomplish a common task.

Stogdill (1969) views leadership as:

...the process (act) of influencing the activities of an organized group in its efforts toward goal setting and goal achievement (p.42).

According to Barnard leadership refers to:

...the quality of the behavior of individuals whereby they guide people or their activities in organized effort (1969, p.83).

For two authors, leadership is seen as:

...the ability based on the personal qualities of the leader, to elicit the followers' voluntary compliance in a broad range of matters [Etzioni (1965, p.690)]

and

...the observed effort of one member (of a group) to change other members' behaviour by altering the motivation of the other members or by changing their habits [Bass (1973, p.43)], (my insert.).

A different view of leadership is given by Klapp (1964):

A symbolic leader is one who functions primarily through his meaning or image (for example, Gandhi meant much as a person to the masses of India - indeed, of the earth - regardless of his official status). Thus I make a distinction between a symbolic leader and an organizational leader....(p.7).

...Symbolic leadership works on masses and audiences prior to, without, and in spite of organization. The "leader" may merely be one to whom many people respond emotionally by identifying with or hating him (the scapegoat, too, is a kind of leader) or a prestigious social type that people imitate. A symbolic leader moves people through his image, the kind of man he seems to be, the style of life or attitude he symbolizes (p.22-23).

If we take the meanings of lead associated with the modern definitions of leadership the core of meaning of leadership can be identified. It is *the relationship between two people when one is changing the intentions of the other.* Changing intentions implies the voluntary compliance of the follower; that is, the leader guides, directs, or influences the follower.

7.3 ESSENTIAL PROPERTIES OF LEADERSHIP

Communication is the means by which a leader changes the followers' intentions, hence the leader and his followers must be purposeful individuals.

The components of leadership are the leader, the followers and the situation:

There are at least four major variables now known to be involved in leadership: (1) the characteristics of the leader; (2) the attitudes, needs and other personal characteristics of the followers; (3) characteristics of the organization, such as its purpose, its structure, the nature of the tasks to be performed; and (4) the social, economic, and political milieu [McGregor (1973, p.20)].

The general conclusion has been that leadership is a relationship among several complex elements, primarily those of (1) the leader; (2) the led; and (3) the situation. [Flippo (1966, p.228)].

The followers must be coproducers of an outcome the leader wants otherwise there would be no need for him to influence them.

The leader's influence can be means-directed or outcome-directed. The latter is more commonly accepted as leadership. In outcome-directed leadership the leader motivates the followers for an outcome i.e. he changes the way the followers value their outcomes.

I believe changing people's values for actions should also be included in leadership, for the following reasons:

(1) In a choice situation an individual can value actions as well as outcomes (i.e. have intentions for actions). Ackoff and Emery (1972, p.42-43) define the valuing of actions as familiarity. Familiarity is to do with an individual's tastes, styles or traits.

The core of meaning of leadership (p. 57) does not exclude changing an individual's intentions for actions.

(2) Several authors (Klapp, Jennings and Bass) indicate that leaders can change the followers' tastes, styles or traits. Bass (refer to page 57) says a leader can change the habits of the followers.

Klapp (1964) obviously believes symbolic leaders change people's tastes or traits as well as the outcomes they seek. He says:

If we ask what this "work" is that the public drama is doing for audiences, an obvious answer is that it is providing models of what to do and how to live ....(p.260).

...faddish symbolic leadership can reorient personalities and shift socialization within our society.

Within the formal structure, then, personality changes that transcend that structure may be occurring by means of symbolic leadership. The emergence of new types as models means that socialization is not following clearly defined, routinized educational tracks. Society is fluid and open, in terms of personality structure and life style (p.262).

I have identified three kinds of leadership:

(1) outcome-directed leadership: the leader changes the follower's intentions for outcomes;

(2) means-directed leadership (familiarization): the leader changes the follower's intentions for actions;

(3) symbolic leadership: the leader changes the follower's intentions for actions and outcomes i.e. does both (1) and (2).

Specification of the conditions which define leadership is arbitrary to a certain extent. I have selected a scheme which enables organising, acquaintance and managing to be defined in a manner similar to leadership. The scheme is described below.

The leader's relative value for the outcome he prefers is the only aspect of his personality which is controlled.

In leadership studies, we are concerned with the effect of the leader's communication on the follower's intentions. The other aspects of the follower's personality must be controlled to remove their potential influence on his intentions. As the follower is considered at two different time-periods - one prior to and one after his receipt of the leader's communication - these aspects must be controlled before, during, and after the communication.

Finally, the leader must have control over the follower. The follower's change in intention produced by the leader must be intentional.

7.4 DEFINITION OF LEADERSHIP

There are three kinds of leadership: outcome-directed leadership, means-directed leadership (familiarization) and symbolic leadership.

(1) Definition of Outcome-directed Leadership

Outcome-directed leadership (O-leadership): one purposeful individual (A) has O-leadership over another individual (B), that is an actual or potential coproducer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's relative value for O_j.

Amount of O-leadership: the amount of O-leadership an individual (A) has over another (B), in an intention situation, for an outcome (O_j) for which $V_{j_A} = 1.0$ and $V_{j_{B_1}} = 0.0$ relative to an exclusive and exhaustive set of outcomes $\{O_j\}_B$ in a choice environment S is the increase in B's relative value for O_j produced by A.

$$L_{j_{AB}} = ((V_{j_{B_2}} - V_{j_{B_1}}) \mid V_{j_A} = 1.0, V_{j_{B_1}} = 0.0, S, \{O_j\}_B)$$

Note: (1) Subscripts A and B refer to individuals A and B respectively.

(2) Subscripts 1 and 2, used for individual B, refer to B's state prior to and after receipt of A's communication respectively e.g. $V_{j_{B_2}}$ is B's relative value after receipt of A's communication.

O-leadership function: A's O-leadership function for an individual (B) and an outcome (O_j) relative to a set of outcomes $\{O_j\}_B$ in an environment S is a mathematical function (f_L) that satisfies the equation

$$L_{j_{AB}} = f_L(V_{j_A}, EV_{B_1}, \{E_{ij}\}_{B_2}, \{DF_{ij}\}_{B_2}, \{DK_{ij}\}_{B_2}, \{DU_{ij}\}_{B_2} \mid S, \{O_j\}_B)$$

Generalised O-leadership function: A's generalized O-leadership function for an individual (B) and an outcome (O_j) is the mathematical function (f_L^*) that satisfies the equation

$$L_{j_{AB}} = f_L^* (V_{j_A}, EV_{B_1}, \{E_{ij}\}_{B_2}, \{DF_{ij}\}_{B_2}, \{DK_{ij}\}_{B_2}, \{DU_{ij}\}_{B_2}, S \mid \{O_j\}_B)$$

(2) Definition of Familiarization (means-directed leadership)

Familiarization: one purposeful individual (A) familiarizes another individual (B), that is an actual or potential coproducer of an outcome (O_j) preferred by A, with a course of action (C_i), which has an efficiency greater than zero for

O_j, when A intentionally produces an increase in B's degree of familiarity with C_i.

Amount of familiarization: the amount of familiarization an individual (A) has for another (B), in a familiarity situation, and a course of action (C_i) relative to an exclusive and exhaustive set of courses of action $\{C_i\}_B$, an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, $L(E_{ij})_{B_1} = L(E_{ij})_{B_2} = 1.0$, and $P_{i_{B_1}} = 0.0$ is the increase in B's probability of choosing C_i produced by A.

$F_{a_{ij_{AB}}} = ((P_{i_{B_2}} - P_{i_{B_1}}) | V_{j_A} = 1.0, V_{j_{B_1}} = V_{j_{B_2}} = 1.0, L(E_{ij})_{B_1} = L(E_{ij})_{B_2} = 1.0, P_{i_{B_1}} = 0.0, \{C_i\}_B)$

Familiarization function: A's familiarization function for another individual (B) and a course of action (C_i) relative to an outcome (O_j) and an available set of courses of action $\{C_i\}_B$ is the mathematical function (f_{F_a}) that satisfies the equation

$$F_{a_{ij_{AB}}} = f_{F_a}(V_{j_A}, EV_{B_1}, V_{j_{B_2}}, L(E_{ij})_{B_2} \mid \{C_i\}_B)$$

There are a number of points which should be noted:

(1) Symbolic leadership can be defined and analyzed in terms of O-leadership and familiarization: no additional definitions are required.

(2) Leadership is a particular type of communication. It is intentional communication directed at one outcome. Its measurement, therefore, is relative to this outcome rather than the whole purposeful state.

It is obvious O-leadership is a particular type of motivation, but it may not be so obvious familiarization is a particular type of information. To inform an individual is to change his probabilities of choice. There are three ways in which this can occur: (a) his values for actions may change, (b) his beliefs in the relative efficiencies of the alternative courses of actions may change, or (c) a combination of (a) and (b).

I disagree with Ackoff and Emery (1972) when they say information has no operational meaning if the alternative courses of action are equally efficient. The changing of people's values for actions is an important part of the socializing process and cannot be overlooked : witness, for example, fashion fads and youth cults.

I further disagree with Ackoff and Emery when they relate information (in their sense) to familiarity. Changing an individual's beliefs in the relative efficiencies of courses of actions has nothing to do with changing his values for those actions as far as I can see. Information (in their sense) is to do with the subject's conception of the situation, not with how he converts his model to an expected value for himself. The only way it can relate to familiarity is in the sense of familiarity <u>with</u> the situation i.e. in relation to how the individual models his situation.

I have stressed this point because the two types are fundamentally different: one is to do with how the receiver models his situation, the other is to do with how he evaluates his model (converts it into an expected value for himself).

I have associated familiarization with change in familiarity and acquaintance (defined in the next chapter) with change in beliefs in the relative efficiencies of courses of actions.

(3) A and B may be psychological individuals, social individuals or purposeful machines without restriction.

(4) A and B may be the same individual.

(5) My definition of leadership makes clear the difficulty some researchers have had comparing the results of leadership studies of small informal groups to those of large organised groups. In the studies no account is taken of the structure of the groups and how this changes during the period of study.

In small informal groups the group degree of knowledge (DK) and degree of understanding (DU) will probably be low (certainly initially) and may change considerably over the period of the study. In large organised groups the DK and DU will probably be high and will be relatively constant over the period of the study.

My definitions take into account group DK and DU and how these affect the group's intentions, so there is no methodological difficulty in relating results from small informal groups to those from large organised groups.

7.5 ANALYSIS OF LEADERSHIP

My definitions of leadership presented so far are incomplete. They measure the amount of change a leader produces in a follower, but give no indication of how well the leader has done. In this context there are four terms which are appropriate: efficient, successful, and effective leadership, and degree of leadership.

(1) *degree of leadership:* the degree of leadership of an individual (A) for another (B) is the ratio of the change in intention produced by A to the maximum amount which could be produced.

$$\text{degree of O-leadership} = \frac{\left(V_{j_{B_2}} - V_{j_{B_1}}\right)_{\text{produced by A}}}{V_{j_{B_{2max}}} - V_{j_{B_1}}}$$

$$\text{degree of familiarization} = \frac{\left(P_{i_{B_2}} - P_{i_{B_1}}\right)_{\text{produced by A}}}{P_{i_{B_{2max}}} - P_{i_{B_1}}}$$

(2) *efficient leadership:* leadership efficiency is the efficiency of the course of action chosen by the leader.

(3) *successful leadership:* the degree of success of leadership is the ratio of the probability of occurrence of the desired outcome to the desired probability of occurrence.

(4) *effective leadership:* this will not be defined, but I shall indicate what should be included in its definition. Effective leadership involves the ideas of degree of leadership, leadership efficiency, leadership success, and the appropriateness of the desired outcome in terms of a larger system's requirements e.g. a society.

7.5.1 Outcome-directed Leadership

The outcome-directed leader changes the followers' intentions for outcomes. The outcomes may be ends, goals, objectives or ideals for the leader and his followers. Different leadership behavior could be expected for each kind of outcome. The only researchers I know who explicitly recognize this point are Vroom and Yetton (1973). They say:
It seems likely that the leadership methods that may be optimal for short-term results may be different from those which would be optimal when executed over a longer period of time (p.44).

One useful way of classifying outcome-directed leaders, then, is according to whether they seek ends, goals, objectives or ideals. Ideal-

seeking leaders can be further sub-classified according to the kind of ideal being pursued. Four main kinds of ideals have been identified by Ackoff and Emery (1972): politico-economic state of plenty, scientific state of truth, ethico-moral state of the good and aesthetic state of beauty.

Outcome-directed leaders can also be studied according to the types of feelings they produce in their followers and the duration of these feelings. Leading for ends will involve short-lived feelings and/or moods. Leading for goals, objectives or ideals will involve short-lived feelings, moods, and/or attitudes.

7.5.2 Familiarization

The variables a familiarizer (means-directed leader) may manipulate to change his followers' degrees of familiarity or familiarity functions may be structurally or functionally defined:

Studies of familiarity involving structurally defined variables (such as color, shape, size, and texture) relate to what is called an individual's taste or style. Studies involving functionally defined variables relate to what psychologists have called personality traits (such as selfishness, generosity, bravery, cowardice, aggressiveness, introversion, cooperativeness) [Ackoff and Emery (1972, p.44)].

Familiarizers may be classified according to whether they change people's tastes (or styles) or traits.

7.5.3 Symbolic Leadership

My conception of symbolic leadership differs slightly from Klapp's. Klapp considers an individual to be a symbolic leader only if he affects a large portion of society. I believe a leader can be a symbol for one individual (the limiting case) and, furthermore, I include the case of a symbolic leader being a group of people (the Beatles were a symbol for many teenagers).

Symbolic leadership includes charismatic leadership. The charismatic leader sets the ideals his followers pursue and represents an ideal way of achieving those ideals. The following quotations illustrate this point:

Charisma is a social phenomenon, not a psychological personality type. [Wilson (1975, p.5)].

...Charisma is a relation of supreme trust in the total competence of an individual, whose qualities are "supernatural, superhuman, or at least specifically exceptional". (Ibid, p.25).

In the case of charismatic authority, it is the charismatically qualified leader as such who is obeyed by virtue of personal trust in him and his revelation, his heroism or his exemplary qualities so far as they fall within the scope of the individual's belief in his charisma.... [Weber (1968, p.46)].

...The term "charisma" will be applied to a certain quality of an individual personality by virtue of which he is set apart from ordinary men and treated as endowed with supernatural, superhuman, or at least specifically exceptional powers or qualities. These are such as are not accessible to the ordinary person, but are regarded as of divine origin or as exemplary, and on the basis of them the individual concerned is treated as a leader (Ibid, p.48).

The charismatic quality of an individual as perceived by others, or himself, lies in what is thought to be his connection with (including possession by or embodiment of) some very central feature of man's existence and the cosmos in which he lives....Contact with this class of vital, "serious" events may be attained through reflective wisdom or through disciplined scientific penetration, or artistic expression, or forceful and confident reality-transforming action [Shils (1965, p.201)].

I believe charismatic leadership is the highest form of leadership.

The symbolic leader becomes more of a symbol as:

(1) the number of followers increases,

(2) the outcomes being sought go from ends to ideals,

(3) the time-period over which he is accepted as leader increases (this accounts for leading over different generations of followers).

He is pure symbol when he is dead yet profoundly influences the succeeding generations.

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THESIS V

There are three kinds of leadership: outcome-directed leadership, means-directed leadership (familiarization) and symbolic leadership (a combination of the first two).

Outcome-directed leadership (O-leadership): one purposeful individual (A) has O-leadership over another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's relative value for O_j.

Amount of O-leadership: the amount of O-leadership an individual (A) has over another (B), in an intention situation, for an outcome (O_j) for which $V_{j_A} = 1.0$ and $V_{j_B} = 0.0$ relative to an exclusive and exhaustive set of outcomes $\{O_j\}_B$ in a choice environment S is the increase in B's relative value for O_j produced by A.

$$L_{j_{AB}} = ((V_{j_{B_2}} - V_{j_{B_1}}) \mid V_{j_A} = 1.0, V_{j_B} = 0.0, S, \{O_j\}_B)$$

O-leadership function: A's O-leadership function for an individual (B) and an outcome (O_j) relative to a set of outcomes $\{O_j\}_B$ in an environment S is a mathematical function (f_L) that satisfies the equation

$$L_{j_{AB}} = f_L(V_{j_A}, EV_{B_1}, \{E_{ij}\}_{B_2}, \{DF_{ij}\}_{B_2}, \{DK_{ij}\}_{B_2}, \{DU_{ij}\}_{B_2} \mid S, \{O_j\}_B)$$

Generalized O-leadership function: A's generalized O-leadership function for an individual (B) and an outcome (O_j) is the mathematical function (f_L^*) that satisfies the equation

$$L_{j_{AB}} = f_L^*(V_{j_A}, EV_{B_1}, \{E_{ij}\}_{B_2}, \{DF_{ij}\}_{B_2}, \{DK_{ij}\}_{B_2}, \{DU_{ij}\}_{B_2}, S \mid \{O_j\}_B)$$

Familiarization (means-directed leadership): one purposeful individual (A) familiarizes another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, with a course of action (C_i), which has an efficiency greater than zero for O_j, when A intentionally produces an increase in B's degree of familiarity with C_i.

Amount of familiarization: the amount of familiarization an individual (A) has for another (B), in a familiarity situation, and a course of action (C_i) relative to an exclusive and exhaustive set of courses of action $\{C_i\}_B$, an outcome (O_j),

$$V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ L(E_{ij})_{B_1} = L(E_{ij})_{B_2} = 1.0, \text{ and } P_{i_{B_1}} = 0.0$$

is the increase in B's probability of choosing C_i produced by A.

$$Fa_{ij_{AB}} = ((P_{i_{B_2}} - P_{i_{B_1}} \mid V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ L(E_{ij})_{B_1} = L(E_{ij})_{B_2} = 1.0,\ P_{i_{B_1}} = 0.0,\ \{C_i\}_B)$$

Familiarization function: A's familiarization function for another individual (B) and a course of action (C_i) relative to an outcome (O_j) and an available set of courses of action $\{C_i\}_B$ is the mathematical function (f_{Fa}) that satisfies the equation

$$Fa_{ij_{AB}} = f_{Fa}(V_{j_A}, EV_{B_1}, V_{j_{B_2}}, L(E_{ij})_{B_2} \mid \{C_i\}_B)$$

CHAPTER 8

ORGANISING

8.1 INTRODUCTION

Leadership, organising and acquaintance can be defined so as to form a set of interpersonal relationships analogous to the three types of communication defined by Ackoff and Emery (1972, p.144-159) - information, instruction and motivation. Leadership is related to motivation and information (in the special sense of Chapter 7), organising is related to instruction and enlightenment, and acquaintance is related to information (in the sense of Ackoff and Emery).

The format of this chapter is different from that of the three previous chapters for two reasons:

(1) an historical analysis of organising and acquaintance[1] was not possible due to a lack of reference sources,

(2) it was assumed organising and acquaintance should be defined in a manner similar to leadership so as to form an integrated set.

A discussion of the meaning of organising and a definition of organising are given in the next section. This is followed by an analysis of the relationship between efficiency and organisation structure. Finally, a definition of acquaintance is presented.

[1] *Footnote: Acquaintance has been included to make my set of definitions complete.*

8.2 DEFINITION OF ORGANISING

My brief analysis of organising indicates its core of meaning to be *to change the interrelationships between the elements of a system so as to increase its efficiency for some outcome.* The following definitions reflect the meaning of organising.

Carlisle (1976, p.331) defines organising as:

...a three-phase process of: (1) designating tasks and activities, (2) grouping these into subunits and positions, and (3) establishing relationships among the resultant elements for the purpose of achieving common objectives.

For Hodgetts (1975, p.161) organising:

...entails the assignment of duties and the coordination of efforts among all organization personnel so as to ensure maximum efficiency in the attainment of predetermined objectives.

Two other authors who consider efficiency to be an important aspect of organising are Allen and Scanlan.

Management organising is the work a manager performs to arrange and relate the work to be done so that it can be performed most effectively by people [Allen (1964, p.163)].

The function of organization involves developing a formal structure which will facilitate the coordination and integration of resources....the organization structure should contribute to the efficient accomplishment of both long and short range plans [Scanlan (1973, p.7)].

Drucker (1974, p.400) says:

...a manager organizes. He analyzes the activities, decisions, and relations needed. He classifies the work. He divides it into manageable activities

and further divides the activities into manageable jobs. He groups these units and jobs into an organization structure. He selects people for the management of these units and for the jobs to be done.

A general definition of organising is given by Fayol (1949):

To organize a business is to provide it with everything useful to its functioning : raw materials, tools, capital, personnel (p.53).

For Koontz and O'Donnell organising:

...involves the establishment of an intentional structure of roles through the determination and enumeration of the activities required to achieve the goals of an enterprise and each part of it, the grouping of these activities, the assignment of such groups of activities to a manager, the delegation of authority to carry them out, and provision for coordination of authority and informational relationships horizontally and vertically in the organization structure (1972, p.48).

Organising is a relationship between one purposeful system (an organiser) and another (the system which is being organised). The product of organising a social individual is an organisation structure i.e. an organised group. If the organiser is a member of the system being organised the product is an organisation.

The aim of organising is to increase the efficiency of the system being organised. The organiser can produce an increase in efficiency by increasing the system's degree of knowledge; hence, organising is clearly related to instruction. The response capabilities of the system may also be improved by increasing its degree of understanding. I believe this idea should be subsumed under organising as well. We require, therefore, two definitions of organising: one relating to the organised system's degree of knowledge

(knowledge-organising) and the other to its degree of understanding (understanding-organising).

(1) Definition of Knowledge-organising

Knowledge-organising (K-organising): one purposeful individual (A) K-organises another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's degree of knowledge of a course of action (C_i) which has an efficiency greater than zero for O_j.

Amount of K-organising: the amount of K-organising an individual (A) has over another (B), in a knowledge situation, for a course of action (C_i) relative to an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, and $DK_{ij_{B_1}} = 0.0$ in a choice environment S is the increase in B's degree of knowledge produced by A.

$$O^K_{ij_{AB}} = ((DK_{ij_{B_2}} - DK_{ij_{B_1}}) \mid V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ DK_{ij_{B_1}} = 0.0,\ S)$$

K-organising function: A's K-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) in a choice environment S is a mathematical function (f^K_o) that satisfies the equation

$$O^K_{ij_{AB}} = f^K_o(V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}} \mid S)$$

Generalized K-organising function: A's generalized K-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) is a mathematical function (f^{K*}_o) that satisfies the equation

$$O^K_{ij_{AB}} = f^{K*}_o(V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}}\ ,\ S)$$

(2) Definition of Understanding-organising

Understanding-organising (U-organising): one purposeful individual (A) U-organises another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's degree of understanding of a course of action (C_i) which has an efficiency greater than zero for O_j.

Amount of U-organising: the amount of U-organising an individual (A) has over another (B), in an understanding situation, for a course of action (C_i) relative to an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, $DU_{ij_{B_1}} = 0.0$ with respect to a state variable (s) in an environment (S') is the increase in B's degree of understanding of C_i produced by A.

$$o^{U}_{ij_{AB}} = ((DU_{ij_{B_2}} - DU_{ij_{B_1}}) \,|\, V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ DU_{ij_{B_1}} = 0.0,\ s,\ S')$$

U-organising function: A's U-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) and a state variable (s) in an environment (S') is a mathematical function (f^{U}_{o}) that satisfies the equation

$$o^{U}_{ij_{AB}} = f^{U}_{o}\,(V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}} \,|\, s,\ S')$$

Generalized U-organising function: A's generalized U-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) is a mathematical function (f^{U*}_{o}) that satisfies the equation

$$o^{U}_{ij_{AB}} = f^{U*}_{o}\,(V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}}\ ,\ s,\ S')$$

U-organising is related to enlightenment.

Efficient, successful and effective organising, and degree of organising can be defined in a manner similar to that for leadership.

(1) *degree of organising:*

(a) The degree of K-organising is the ratio of the increase in efficiency produced by the organiser to the maximum increase possible. It involves the amount of K-organising an organiser produces and the maximum relative efficiency of the course of action relative to which he organises an individual.

$$\text{degree of K-organising} = \frac{\left(E_{ij_{B_2}} - E_{ij_{B_1}}\right)_{\text{produced by A.}}}{E_{hj_{B_{2max}}} - E_{ij_{B_1}}}$$

where $h \leq i$, and the h'th course of action is the most efficient relative to the available set of courses of action.

(b) The degree of U-organising is the ratio of the increase in the probability of production of an outcome (O_j) produced by the organiser to the maximum increase possible.

$$\text{degree of U-organising} = \frac{\left(P(O_j)_{B_2} - P(O_j)_{B_1}\right)_{\text{produced by A.}}}{P(O_j)_{B_{2_{max}}} - P(O_j)_{B_1}}$$

(2) *organising efficiency:* is the efficiency of the course of action chosen by the organiser.

(3) *successful organising:* the degree of success of organising is the ratio of the probability of occurrence of the desired outcome to the desired probability of occurrence.

(4) *effective organising:* this involves degree of organising, organising efficiency, successful organising and the appropriateness of the organisation structure relative to a supra-system (the system of which the organised system is an element).

8.3 THE RELATIONSHIP BETWEEN EFFICIENCY AND ORGANISATION STRUCTURE

To simplify the following discussion I shall consider K-organising only, but the comments made are applicable to U-organising as well.

In the knowledge situation we formulate a set of sub-courses of action which are exclusive and exhaust a defined course of action. The efficiencies of these sub-courses of action are objective i.e. independent of the subject. Each sub-course of action is a different way of performing the course of action and has a measurable efficiency.

An organised group has a division of labour relative to its objective. There are many ways of dividing the work to be done among the members of the group. Each corresponds to a different organisation structure which will have a certain efficiency associated with it. It is possible to define a course of action so that the different ways of dividing the work to be done are sub-courses of action. Each sub-course of action is equivalent to performing the work to be done using a particular organisation structure.

Ackoff and Emery (1972) have provided a measure of efficiency of organisation structure in terms of gain and loss functions. They state that maximum efficiency is achieved when the sub-groups responsible for the gain and loss functions are independent:

Then, because the gain and loss are independent

$$max_{x,y}\ [f_1(X) - f_2(Y)] = max_x\ [f_1(X)] - min_y\ [f_2(Y)].$$

The division of labor (organizational structure) in this situation has no inherent inefficiency; if each subgroup obtains its subobjective, the group as a whole will obtain its objective (p.223).

The minimum efficiency, I believe, is associated with the unorganised group. In this case no individual in the group makes a choice on the group's behalf. The gain and loss functions are not assigned to any sub-group but are both functions of the group as a whole.

Ashby (1960) has shown a system can consist of sub-systems with varying degrees of connectedness - from fully joined to completely independent sub-systems. Furthermore, he shows the time for adaptation is extremely large for the fully joined system i.e. it has the lowest efficiency.

The unorganised group corresponds to a fully joined system - there is a maximum degree of connectedness between the gain and loss functions - hence, it will have minimum efficiency.

An organiser by increasing the degree of knowledge of a group is increasing its probabilities for selecting the sub-courses of action with higher efficiencies. These correspond to organisation structures with higher efficiencies and which are relatively less connected between the gain and loss functions compared to structures with low efficiencies.

The various types of formal organisation structures can be classified according to the two kinds of organising I have defined. The K-type structures will have a high efficiency in a given environment and the U-type will be highly responsive to change in efficiency. The ideal structure will be one which is both a K-type and a U-type. Figure 8.1 shows some formal structures classified according to my scheme.

The semi-autonomous and autonomous work groups represent the best achievement to date: a high efficiency combined with a high responsiveness to change in efficiency.

8.4 DEFINITION OF ACQUAINTANCE

A person becomes acquainted with a course of action when his degree of belief in its relative efficiency for an outcome increases. Acquaintance is clearly related to information in the sense of Ackoff and Emery.

Acquaintance: one purposeful individual (A) acquaints another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, with a course of action (C_i), which has an efficiency greater than zero for O_j, when A intentionally produces an increase in B's degree of belief in the maximum relative efficiency of C_i for O_j.

Amount of acquaintance: the amount of acquaintance an individual (A) has with another (B), in a belief situation, and a course of action (C_i) relative to an exclusive and exhaustive set of courses of action $\{C_i\}_B$, an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, $P_{i_{B_1}} = 0.0$, $L(DI_i)_{B_1} = L(DI_i)_{B_2} = 1.0$ is the increase in B's probability of choosing C_i produced by A.

$$A_{ij_{AB}} = ((P_{i_{B_2}} - P_{i_{B_1}}) \mid V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ L(DI_i)_{B_1} = L(DI_i)_{B_2} = 1.0,\ P_{i_{B_1}} = 0.0\ ,\ \{C_i\}_B).$$

where DI_i = degree of intention for course of action i (C_i), and $L(DI_i)$ = $DI_1 = DI_2 = DI_2 \ldots\ldots = DI_i$

$L(DI_i)$ is the level of the degree of intention for the available courses of action.

Acquaintance function: A's acquaintance function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) and an available set of courses of action $\{C_i\}_B$ is a mathematical function (f_A) that satisfies the equation

$$A_{ij}{}_{AB} = f_A(V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}}\ ,\ L(DI_i)_{B_2} \mid \{C_i\}_B)$$

Efficient, successful and effective acquaintance can be defined as for organising. Degree of acquaintance can be defined as follows:

$$\text{degree of acquaintance} = \frac{\left(P(O_j)_{B_2} - P(O_j)_{B_1}\right)_{\text{produced by A.}}}{P(O_j)_{B_{2_{max}}} - P(O_j)_{B_1}}$$

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THESIS VI

There are two kinds of organising: Knowledge-organising and Understanding-organising.

Knowledge-organising (K-organising): one purposeful individual (A) K-organises another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's degree of knowledge of a course of action (C_i) which has an efficiency greater than zero for O_j.

Amount of K-organising: The amount of K-organising an individual (A) has over another (B), in a knowledge situation, for a course of action (C_i) relative to an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, and $DK_{ij_{B_1}} = 0.0$ in a choice environment S is the increase in B's degree of knowledge produced by A.

$$O^{K}_{ij_{AB}} = ((DK_{ij_{B_2}} - DK_{ij_{B_1}}) \,|\, V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ DK_{ij_{B_1}} = 0.0\ ,\ S)$$

K-organising function: A's K-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) in a choice environment S is a mathematical function (f^{K}_{o}) that satisfies the equation

$$O^{K}_{ij_{AB}} = f^{K}_{o}\ (V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}} \,|\, S)$$

Generalized K-organising function: A's generalized K-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) is a mathematical function (f^{K*}_{o}) that satisfies the equation

$$O_{ij_{AB}} = f^{K*}_{o}\ (V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}}\ ,\ S)$$

Understanding-organising (U-organising): one purposeful individual (A) U-organises another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's degree of understanding of a course of action (C_i) which has an efficiency greater than zero for O_j.

Amount of U-organising: the amount of U-organising an individual (A) has over another (B), in an understanding situation, for a course of action (C_i) relative to an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, $DU_{ij_{B_1}} = 0.0$ with respect to a state variable (s) in an environment (S') is the increase in B's degree of understanding of C_i produced by A.

$$O^{U}_{ij_{AB}} = ((DU_{ij_{B_2}} - DU_{ij_{B_1}}) \,|\, V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ DU_{ij_{B_1}} = 0.0,\ s,\ S')$$

U-organising function: A's U-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) and a state variable (s) in an environment (S') is a mathematical function of (f^{U}_{o}) that satisfies the equation

$$O^{U}_{ij_{AB}} = f^{U}_{o}\ (V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}} \,|\, s, S')$$

Generalized U-organising function: A's generalized U-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) is a mathematical function (f^{U*}_{o}) that satisfies the equation

$$O^{U}_{ij_{AB}} = f^{U*}_{o}\ (V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}}\ ,\ s,\ S')$$

THESIS VII

Acquaintance: one purposeful individual (A) acquaints another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, with a course of action (C_i), which has an efficiency greater than zero for O_j, when A intentionally produces an increase in B's degree of belief in the maximum relative efficiency of C_i for O_j.

Amount of Acquaintance: the amount of acquaintance an individual (A) has with another (B), in a belief situation, and a course of action (C_i) relative to an exclusive and exhaustive set of courses of action $\{C_i\}_B$, an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, $P_{i_{B_1}} = 0.0$, $L(DI_i)_{B_1} = L(DI_i)_{B_2} = 1.0$ is the increase in B's probability of choosing C_i produced by A.

$$A_{ij}{}_{AB} = ((P_{i_{B_2}} - P_{i_{B_1}}) \mid V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ L(DI_i)_{B_1} = L(DI_i)_{B_2} = 1.0,\ P_{i_{B_1}} = 0.0,\ \{C_i\}_B)$$

Acquaintance function: A's acquaintance function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) and an available set of courses of action $\{C_i\}_B$ is a mathematical function (f_A) that satisfies the equation

$$A_{ij}{}_{AB} = f_A(V_{j_A},\ EV_{B_1},\ V_{j_{B_2}},\ L(DI_i)_{B_2} \mid \{C_i\}_B)$$

CHAPTER 9

MANAGEMENT: AN INTEGRATING CONCEPT

9.2 INTRODUCTION

The history of management thought extends back to the ancient civilizations.(1) As early as the tenth century B.C. Solomon (King of Israel) is recorded as having established elaborate trade agreements, managed construction projects (for example, the building of a large temple at Yahweh), and moulded peace agreements.

Some of the oldest written documents that have ever been found are temple records of the Sumerian civilization of about 3000 B.C. The Sumerian temple priests, through their vast tax system, collected and handled tremendous amounts of worldly goods. To manage this system the priests developed a system of recording their transactions : an early example of managerial control.

The construction of the pyramids from 5000 B.C. to 525 B.C. is mute testimony of the planning and organising skill of the Egyptians. Written evidence of their thoughts on management is given in the book of instruction Ptah-hotep (supposedly composed about 2700 B.C.) and a manuscript entitled aboyet.

The Babylonians developed business laws - the Code of Hammurabi (approx. 2000 B.C.) - and used production control and incentive wage payments in their textile mills (about 600 B.C.).

(1) *Footnote: For a full account of the history of management thought refer to George (1968).*

The records of the Chinese philosophers Mencius and Chow (1100 B.C. to about 500 B.C.) indicate the Chinese were aware of certain principles concerning organising, planning, directing and controlling. They were the first to recognize the need for a methodological means of employee selection and staffing.

Extensive documentation of management principles is provided by the Greeks. For example, Xenophon wrote about the universality of management, specialization, management as an art, employee selection, delegation of authority, and motion study.

The Romans displayed their managerial talents by organising and controlling a large and far-reaching empire.

During the period following the downfall of Rome and up to the Renaissance virtually no further progress was made in management thought. Two notable writers of that period, however, were Sir Thomas More and Niccolò Machiavelli. More, an idealist, wrote about the management of an ideal society. Machiavelli, on the other hand, was a realist and described the world as he observed it.

The 19th century saw a reawakened interest in management thought. From the early 19th century writers many different approaches to the study of management and managers developed. Six major schools have been classified by Koontz (1971). These are:

(1) the management process school, which views management as a process of getting things done through and with people operating in organised goups - the process is divided into functions for analysis;

(2) the empirical school, which identifies management as a study of experience;

(3) the human behavior school, which considers interpersonal relationships to be most important for managers;

(4) the social system school, which views management as a system of cultural interrelationships;

(5) the decision theory school, which concentrates on managerial decision-

making and the rational approach to taking decisions; and

(6) the mathematical school, which sees management as a system of mathematical models and processes.

With the wealth of experience to draw upon one would expect a general theory of management to be well developed today; but this is not the case, as two authors observe:

The noteworthy absence of academic writing and research in the formative years of modern management theory is now more than atoned for by a deluge of research and writing from the academic halls....[Koontz (1971, p.4)].
...This welling of interest from every academic and practicing corner should not upset anyone concerned with seeing the frontiers of knowledge pushed back and the intellectual base of practice broadened. But what is rather upsetting to the practitioner and the observer, who sees great social potential from improved management, is that the variety of approaches to management theory has led to a kind of confused and destructive jungle warfare (Ibid, p.5).

Now managing is a type of behavior, and since it's a very important type of behavior, you might expect that we know a great deal about it. But we don't at all....The whole activity of managing, important as it is for the human race, is still largely an unknown aspect of the natural world. When man detaches himself and tries to observe what kind of living animal he is, he finds that he knows very little about the things most important to him and precious little about his role as a decision maker [Churchman (1968, p.19-20)].

I believe the integration of the different viewpoints into a general theory of management and the development of that theory requires a rigorous definition of management. The definition must include all viewpoints and provide a standard so that the research results derived from the different

approaches can be related. In this chapter I propose and discuss a definition which satisfies these conditions.

9.2 ESSENTIAL PROPERTIES OF MANAGEMENT

Leading and organising, which relate to particular aspects of the personality of the individual being led or organised, are two of the most commonly cited managerial functions. Management, therefore, must relate to the whole personality of the individual being managed i.e. his expected value[1]. The manager increases the individual's expected value for an outcome he (the manager) wants.

The generality of this conception of management is illustrated by the following definitions which are encompassed by it.

For Sisk (1969) management is:

...the coordination of all resources through the processes of planning, organising, directing, and controlling in order to attain stated objectives (p.10).

Allen (1973, p.26) says:

Management...is the ability to get other people to work with you and for you to accomplish common objectives.

Brech describes management as:

A social process entailing responsibility for the effective (or efficient) planning and regulation of the operations of an enterprise, such responsibility involving - (a) the installation and maintenance of proper procedures to ensure adherence to plans : and (b) the guidance, integration and supervision of the personnel comprising the enterprise and carrying out its operations (1962, p.30).

[1] *Footnote: As I assume management relates to the expected value of the individual being managed there is no need to conduct an historical analysis to identify its core of meaning.*

Two general definitions of manager are given by Churchman and Vickers:

The manager is the man who decides among alternative choices. He must decide which choice he believes will lead to a certain desired objective or set of objectives....[Churchman (1968, p.17)].

...I want to add one more stipulation that makes the label manager less general. This is the stipulation that managerial activity take place within a "system": The manager must concern himself with interrelated parts of a complex organization of activities, and he is responsible for the effectiveness of the whole system... (Ibid, p.18).

I have described the managers of an undertaking - <u>any</u> undertaking - as regulators of a system or sub-system; concerned to regulate its internal and external relations with a view both to preserving its essential balances and to optimizing the multiple results of its activities. [Vickers (1967, p.85)].

Fulmer (1974) has this view of the manager:

The manager is many people. He is a historian, trying to benefit from the experience of others; a psychologist, giving heed to the characteristic nature of people; a social scientist, recognizing that group status is a highly significant management tool; a logician, utilizing the latest decision making techniques; and a mathematician, using a systematic approach to problem solution ....The tools of the manager craftsman are planning, organizing, staffing, controlling, and directing. (p.85-86).

For Duncan:

Management consists of all organizational activities that involve goal formation and accomplishment, performance appraisal, and the development of an operating philosophy that ensures the organization's survival within the social system (1975, p.5).

A definition of management that integrates the managerial functions leadership, organising and acquaintance will have to be similar in form to their definitions. In the management situation, then, we control the manager's relative value for the outcome he wants and the initial expected value of that outcome to the individual being managed.

9.3 DEFINITION OF MANAGEMENT

Management: One purposeful individual (A) manages another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's expected value for O_j.

Amount of management: The amount of management an individual (A) has over another (B) relative to an outcome (O_j), $V_{j_A} = 1.0$ and $EV_{j_{B_1}} = 0.0$ in a choice environment S is the increase in B's expected value for O_j produced by A.

$$M_{j_{AB}} = ((EV_{j_{B_2}} - EV_{j_{B_1}}) \mid V_{j_A} = 1.0,\ EV_{j_{B_1}} = 0.0,\ S)$$

Management function: A's management function for an individual (B) relative to an outcome (O_j) in an environment S is the mathematical function (f_m) that satisfies the equation

$$M_{j_{AB}} = f_m\ (V_{j_A}\ ,\ EV_{B_1} \mid S)$$

Generalized management function: A's generalized management function for an individual (B) relative to an outcome (O_j) is the mathematical function (f_m^*) that satisfies the equation

$$M_{j_{AB}} = f_m^*(V_{j_A}\ ,\ EV_{B_1}\ ,\ S)$$

9.4 ANALYSIS OF MANAGEMENT

According to my scheme leadership, organising and acquaintance are a mutually exclusive and exhaustive set of managerial functions. Some justification for the scheme is provided by Mintzberg's (1973) empirical study of the behavior of managers. He identified ten managerial roles, defined in Figure 9.1, and classified these into three main groups : informational, interpersonal and decisional (refer to Fig. 9.2). The groups correspond to acquaintance, leadership and organising respectively.

Mintzberg also identified eight managerial job types, shown in Figure 9.2. Obviously some job types mainly involve one function (or role) only. We can conclude, therefore, that a manager is an individual that leads, organises or acquaints, or performs some combination of these. The highest kind of management will be one which involves all three functions.[1] If a manager performs all three functions and seeks ideals then he can be called a *charismatic* manager - the highest type of manager.

Efficient, successful, and effective management, and degree of management can be defined as follows.

(1) *degree of management:* this is the ratio of the increase in expected value produced by the manager to the maximum increase possible.

$$\text{degree of management} = \frac{\left(EV_{jB_2} - EV_{jB_1}\right) \text{ produced by A}}{EV_{jB_{2max}} - EV_{jB_1}}$$

(2) *management efficiency:* the efficiency of the course of action chosen by the manager.

[1] *Footnote: It seems to me that some studies of "leadership" are in fact studies of this kind of management.*

(3) *management success:* the degree of success is the ratio of the probability of occurrence of the desired outcome to the desired probability of occurrence.

(4) *management effectiveness:* this involves management efficiency and success, degree of management, and the appropriateness of the managerial behavior for a larger system. The appropriateness of managerial behavior involves (a) the "rightness" of the outcome and/or action with regard to which the followers are changed and (b) the "rightness" of the particular change the manager produces in his followers relative to the larger system.

The reader may have noticed that I have not defined leader, manager, etc. The omission is deliberate because definition of those terms will depend on the purposes of the research. It seems appropriate, however, to conclude this chapter by indicating how they might be defined.

The manager, leader, etc. can be defined as the individual that has:

(1) the greatest relative influence over another individual or group i.e. has highest $M_{j_{AB}}$, $L_{j_{AB}}$, etc; or

(2) an amount of influence ($M_{j_{AB}}$, $L_{j_{AB}}$, etc.) greater than some specified figure. For example: a manager is an individual that has $M_{j_{AB}} \geq .5$.

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THESIS VIII

Management: One purposeful individual (A) manages another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's expected value for O_j.

Amount of management: The amount of management an individual (A) has over another (B) relative to an outcome (O_j), $V_{j_A} = 1.0$ and $EV_{j_{B_1}} = 0.0$ in a choice environment S is the increase in B's expected value for O_j produced by A.

$$M_{j_{AB}} = ((EV_{j_{B_2}} - EV_{j_{B_1}}) \mid V_{j_A} = 1.0,\ EV_{j_{B_1}} = 0.0,\ S)$$

Management function: A's management function for an individual (B) relative to an outcome (O_j) in an environment S is the mathematical function (f_m) that satisfies the equation

$$M_{j_{AB}} = f_m(V_{j_A}\ ,\ EV_{B_1} \mid S)$$

Generalized management function: A's generalized management function for an individual (B) relative to an outcome (O_j) is the mathematical function (f_m^*) that satisfies the equation

$$M_{j_{AB}} = f_m^*(V_{j_A}\ ,\ EV_{B_1}\ ,\ S)$$

CHAPTER 10

NEW ZEALAND ENGINEERING INDUSTRY TRAINING BOARD TECHNICAL MANPOWER SURVEY: A PRACTICAL ILLUSTRATION OF DEFINING

10.1 INTRODUCTION

The reader may be questioning the practical utility of the idealized operational definitions and theoretical analyses presented in the preceding chapters. In this chapter I intend to show how the preceding work was successfully used to survey technical manpower activities in the New Zealand manufacturing and processing industry. First, however, background information about the survey is presented.

A Technical Manpower Training Committee was formed by the New Zealand Engineering Industry Training Board, in 1974, to examine the present educational and training programmes appropriate to technicians, technician engineers and technologists, and to recommend possible changes in these programmes.

At a meeting of the Committee on 18th March 1975 it was decided to conduct a detailed survey of the educational and training needs of technicians, technician engineers, and technologists in industry.

The survey was intended to indicate the present employment distribution of engineers, indicate a method of classifying engineers according to the work they perform, indicate those areas where detailed research might be conducted, and provide a framework for later research and surveys.

The author, in conjunction with Professor McCallion, was invited to design and plan the survey, and to analyse the results. Work began on the survey in March 1976. The first stage was implemented in November 1976 and

the second stage in October 1977.

The requirement for the survey to provide a framework for future scientific research meant a rigorous conceptual model should be used as its foundation. Such a model would ensure future surveys could be related to each other and prevent work being repeated unnecessarily. The conceptual model expounded by Ackoff and Emery (1972) was chosen, and extended for the purposes of the survey.

It was realized at an early stage that questionnaires would be sent to each engineer in the population. The concepts which were to be surveyed are difficult to understand; therefore it was essential the questionnaire contained definitions of those concepts if consistent interpretation by respondents was to be achieved. The questionnnaire definitions were developed from idealized operational definitions.

This discussion regarding the survey will be concerned only with how important technical manpower activities were selected and defined, and the results relating to the interpretations of the personal questionnaire by respondents.

10.2 TECHNICAL MANPOWER SKILLS

The last section of the personal questionnaire (see Appendix 6) deals with skills. The word *task* was used in the questionnaire, instead of *skill*, because pilot testing of the questionnaire showed interpretations of skill were more confused and varied than those of task.

To discuss skills we first need a definition of skill.

Skill: a course of action which has a high expected value (EV) for each outcome in a set of outcomes for a significant portion of those who choose it.

It is not possible to say what value of EV, range of outcomes, or portion of individuals must exist before a course of action may be called a skill. With regard to an outcome (O_j) for which an individual has a relative value (V_j) of 1.0, a course of action is generally called a skill only if execution of it will produce O_j with a high probability i.e. an individual must choose the action with a high probability and perform it with a high efficiency.

The technical manpower skills chosen were: communication, controlling, planning, designing, negotiating, organising and manipulation. The reasons for this selection were:

(1) Communication - by definition on organisation requires communication between any one of its members and at least one other of its members some of the time. Hence communication is an essential aspect of all organisations.

(2) Organising and controlling - in a social group extended over time and space a number of secondary tasks are needed to provide the integration necessary for it to achieve its common purpose. Organising and controlling are considered to be two such tasks.

(3) Planning - if an organisation is to achieve its common objective at least some of the time then it must be able to anticipate potential future difficulties i.e. it must plan.

(4) Designing - this is a traditional and important engineering activity.

(5) Manipulation - all production organisations use instruments, hence their manipulation is important. It was also hoped choice situations involving manipulative skills would provide a means for differentiating between professional engineers and technicians.

(6) Negotiating - this is an important interaction between an organisation and its environment.

The choice situations, within which those skills are performed, were classified by their components. It was intended that later research be conducted to determine the parameters of choice for skilful behavior in those situations. Four components were used to classify choice situations: (1) subject (respondent), (2) courses of action, (3) outcomes, (4) choice environment. I will now discuss each skill and show how the choice situations were classified using the four components.

10.2.1 Communication

(1) Idealized Definition:

One purposeful individual (B) communicates to another (A) when a message produced by B produces a change in one or more of the parameters (P_i , E_{ij} , V_j) of A's purposeful state. [Ackoff and Emery (1972), p.142].

(2) Questionnaire Definition:

The production of messages which will inform, instruct or motivate the receivers of your messages as you intend.

(3) Classification

(a) Subject and Choice Environment

The individual A to whom B is communicating is part of B's choice environment. If B is to produce the response he intends then his message must be semantically and pragmatically efficient for A i.e. A and B must share a common language. One useful way, then, of classifying the individual A's and B's is by the language they have in common.

A language is defined as a set of signs and instructions; the amount in common between A's and B's languages can be defined in terms of set theory. The most important languages with regard to engineering are those known as *technical* languages, and are the only ones considered for the survey.

Technical language: any language which is semantically and pragmatically efficient for the engineering profession but which has no or a low semantic and pragmatic efficiency for people not in the profession.(1)

The following classification was developed from the above concepts:

(1) A has <u>little or no</u> knowledge of B's technical language if

$$0 \leq \frac{\{x_A\}}{\{x_B\}} \leq .33 \quad , \qquad \text{where}$$

$\{x_B\}$ is the set of signs and instructions of B's technical language, $\{x_A\}$ is a sub-set of $\{x_B\}$ and is the set of signs and instruction of B's technical language which A knows.

(2) A has <u>some knowledge but less than</u> B of B's technical language if

$$.33 < \frac{\{x_A\}}{\{x_B\}} \leq .67$$

(3) A has the <u>same</u> technical language as B if

$$.67 < \frac{\{x_A\}}{\{x_B\}} \leq 1.0$$

With the three-fold classification above and that of sender/receiver it is possible to obtain five types of situation. Only four types were used in the survey because the class '<u>sender</u>, with <u>general knowledge</u> of a technical language' does not apply - all the respondents are technically qualified. The subjects were further classified into two classes - professional engineer and technician.

(b) <u>Outcome</u>

The outcome of a communication is a message and a change in the parameters of the receiver's purposeful state. The latter was not considered

(1) *Footnote: the people in the engineering profession can be considered those who satisfy the criteria of a qualified engineer given on p. 5 - 6.*

because it involves a detailed analysis of the communication process. The messages, however, can be classified according to their denotations and connotations. This was carried out by using the broad concept of *technical situation* i.e. the messages connoted a technical situation. Messages were also sub-classified according to whom they were sent and what they were about.

Firstly, messages were classified according to how they were produced i.e. the structure of the signs. The most important types were considered to be written, oral and enactive. Typical examples of each type are:

Written: letters, reports, drawings,

Oral: lectures, talks, interviews, demonstrations,

Enactive: demonstrations.

Secondly, they were classified according to their content i.e. what they were about. For example, reports from testing state of material.

Part of the question on communication is shown in Figure 10.1. Note that the classification of outcomes - in terms of papers, reports, lectures, etc. - was not only used to obtain relevant information about the kinds of messages respondents produced, but also to clarify the definitions of the different types of communication situations.

10.2.2 Controlling

(1) Idealized Definition:

(a) Amount of control (β_{ij}) an individual has over a particular course of action (C_i) relative to a particular outcome (O_j):

$$\beta_{ij} = (E_{ij} | V_j = 1.0) - (E_{ij} | V_j = 0)$$

(b) Amount of control (β_i) an individual has over a particular course of action (C_i) relative to a set of n outcomes:

$$\beta_i = \sum_{j=1}^{n} \beta_{ij}$$

(c) Amount of control (β) an individual has in a purposeful state relative to a set of m courses of action and a set n outcomes:

$$\beta = \sum_{i=1}^{m} \beta_i = \sum_{i=1}^{m} \sum_{j=1}^{n} \beta_{ij}$$

[Ackoff and Emery (1972, p.154)]

(2) Questionnaire Definition

The observation of your own or other people's behaviour, or the performance of technical equipment, and the inference and implementation of adjustments to correct deviations from the intended results.

(3) Classification

(a) Subjects and Choice Environment

No classification was developed for the choice environment. Subjects were classified into two classes - professional engineer and technician.

(b) Outcome

The amount of control in a purposeful state is measured relative to a set of outcomes. Twenty-two outcomes believed to be significant for engineers were identified (see Figure 10.2, part (a)).

(c) Courses of Action

Control of a group implies the use of a plan. The amount of control a person has in a purposeful state is defined in terms of an exclusive and exhaustive set of courses of action. An individual in an organisation may not have the complete set available to him, i.e. other individuals may restrict his choice by removing instruments from his environment or by influencing his parameters of choice. Clearly the amount of control will be related to his set of potential courses of action. These were classified in terms of:

(1) modifying the intended outcomes of the system being controlled i.e. an individual may be able to change the plan,

(2) re-organising the social group being controlled,

(3) changing the group's instruments,

(4) changing the parameters of the purposeful states of the people in the group.

Although an individual may co-produce a change in those variables he may not have full discretion to do so. A measure was sought of the amount of control an individual has for producing those changes when change-productions are outcomes: a two-fold classification was developed. (Refer to Figure 10.2, part (B)).

10.2.3 Manipulation

The use of instruments was classified using the concepts familiarity, knowledge and understanding given in Ackoff and Emery (1972). The classification also included an individual's beliefs of another's use of instruments.

Part of the question is shown in Figure 10.3.

10.2.4 Planning

(1) Idealized Definition[1]

A purposeful individual (A) plans, if in a choice environment S in a time-period t_1 - t_2:

(1) A produces a message O_1 connoting two or more essential properties $\{p_x\}$ of an available course(s) of action of another individual C, who exists at time t_1, in a choice environment S_j at t_j for C to produce an outcome (O_k) at t_k ($t_k > t_j > t_2$);

[1] *Footnote: This definition is different from that given in Chapter 6. The latter is the result of further research conducted after the survey.*

(2) the message (O_1) is a potential producer of O_k;

(3) at time t_1 , A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ in S such that the union of $\{p_s\}$ and $\{p_1\}$ exhaust $\{p_x\}$.

The set of properties $\{p_x\}$ is the plan.

(2) Questionnaire Definition:

The production of a message describing the action or results you intend a group of people to produce at some future time.

(3) Classification

(a) Subject

Classified according to the two engineering classes.

(b) Choice Environment

C may be a group of people and, if so, will be part of A's choice environment. An approximate measure of the complexity of the choice environment was obtained by determining the number of people in the group being planned for.

(c) Outcome

The outcome is a plan. Using Ackoff's scheme (1970) this can be classified according to its range and end-means orientation. The latter was not considered because it requires a detailed analysis of the content of plans.

The range is the time-period an individual must look ahead to produce the plan. The time-periods were divided into three classes:

(1) up to and including one year,

(2) over one year and up to three years,

(3) over three years.

The justification for this scheme is detailed below:

(1) One year cut-off: most companies plan one year in advance because it is accepted accounting practice. To plan for over one year, however, requires taking into account likely changes in

(a) the Government budget,

(b) the Government taxation,

(c) competitors', suppliers', etc. yearly financial policies.

I believe planning over one year requires a different personality function to that required for planning up to one year.

(2) Three year cut-off: The N.Z. Government is elected every three years. Planning for over three years requires taking into account either (1) changes in Government or (2) likely changes in Government policies. I hypothesized that a different personality function would be required to plan for over three years from that required to plan for less than three years.

A plan may apply to various sub-groups of an organisation. The larger the portion of the organisation to which a plan applies the more strategic it becomes. Four main groups were identified:

(1) planning for small groups e.g. sections in a firm,

(2) planning for a major function in the firm,

(3) planning for the firm as a whole in terms of resource allocation,

(4) planning for the firm as a whole in terms of company objectives and policy.

Part of the planning question is shown in Figure 10.4

10.2.5 Designing

(1) Idealized Definition

A purposeful individual (A) designs, if in a choice environment S in a time-period $t_1 - t_2$:

(1) A produces a message M_1 connoting two or more essential properties $\{p_x\}$ of a concrete system(s) or object(s), which does not exist in any environment at time t_1;

(2) the message (M_1) is a potential producer of at least one essential structural property of the system(s) or object(s) in some environment S_j;

(3) at time t_1, A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ by S such that the union of $\{p_1\}$ and $\{p_s\}$ exhausts $\{p_x\}$.

The set of properties $\{p_x\}$ is the design.

(2) Questionnaire Definition:

The production of a message describing the essential features of a new object/system/procedure/method so that it can be produced.

(3) Classification

(a) Subject

The two-fold engineering classification was used.

(b) Choice environment

A becomes aware of sub-set $\{p_1\}$ by a message. A may receive a message connoting $\{p_1\}$ from someone else, and send a message connoting $\{p_x\}$ to someone else. This happens frequently in industry and formed the basis of an environmental classification.

A message may connote images, concepts or a combination of these. I assumed different personality functions would be required to produce messages connoting concepts and messages connoting images. The choice situation was

classified according to the types of messages the designer receives and produces (see Figure 5.3, p.35).

For the survey, differentiation was made between the designer and client being two different people, and the designer and client being the same person. Consequently, it was necessary to include three other design situations:

(1) - specific functional: designer does not receive a message from someone else, but produces a specific functional message.

(2) - general structural,

(3) - specific structural.

Unfortunately it was not realised these three design situations should have been included separately until the interviews were conducted. This aspect is discussed more fully on page 109.

The question relating to the above classification is shown in Figure 10.5.

(c) Outcome

An attempt was made to classify outcomes according to the novelty and complexity of the design. The attempt was not successful, so it was decided to classify outcomes according to the type of system designed. This does provide a rough measure of design complexity.

10.2.6 Negotiating

(1) Idealized Definition:

An individual (A) negotiates with another (B) when:

(1) A prefers a thing X_1 to another thing X_2;

(2) B prefers X_2 to X_1;

(3) A believes B is necessary for X_1 to occur and he is necessary for X_2 to occur;

(4) A communicates to B his intention to co-produce X_2 if B will communicate his intention to co-produce X_1.

'Thing' represents either objects, events, their properties or combinations of these.

(2) Questionnaire Definition:

Bargaining for the exchange of valued possessions, as a principal or as an agent of the firm.

(3) Classification

(a) Subject

Classified according to the two engineering classes.

(b) Choice Environment

Classified in terms of the types of individuals engineers were expected to negotiate with (See Figure 10.6).

10.2.7 Organising

I had considerable difficulty in formulating an idealized definition of organising in the limited time available. As a result all I asked in the questionnaire was: do you organise a group of people? The following definition of organising was provided.

> Organising: the allocation or assignment of tasks to people and the co-ordination and integration of their behaviour.[1]

10.3 RESULTS

Controlling, planning, and designing questions, on which much effort had been expended during questionnaire design and pilot testing to ensure completeness and clarity, still caused problems during the main survey.

[1] *Footnote: The reader should note that organising, leadership and managing were defined after the survey was completed.*

(1) Controlling

The main mistake was that for part (b), the situation in which a person may take corrective action for factors which he did not measure or monitor was not included. Consequently, the numbers obtained for part (b) will be an underestimate.

Results from the interviews indicated measuring or monitoring factors relating to people outside the firm may be an activity which is performed by a significant percentage of engineers. This possibility was allowed for in Q.11(a) 9 (see Figure 10.2); but unfortunately it was not detailed as now appears necessary.

(2) Planning

Preoccupation with personnel within companies blinded me to the fact that people in a firm may plan for people in its environment. This was brought to my attention by several engineers at New Zealand Forest Products (Kinleith) whose main task was to plan and co-ordinate the behavior of sub-contractors.

The result of omitting planning for people in the firm's environment is that not all the people who plan may have been identified.

Some people were confused by the definitions of the different types of planning situations. An analysis of the replies and interviews gives an estimated figure of less than 5% for the portion of respondents who misinterpreted part (a) of the planning question.

(3) Designing

Replies to this question highlighted the major failure of the questionnaire - the term *message* was not defined. Interpretation of what constituted a message varied considerably and resulted in a 7% error in replies to Q.14 part (b) i.e. 7% of the respondents who ticked (a) did not tick any boxes for

'message produced' in part (b). Some respondents said they had not considered a drawing as a message. Others did not consider suggestions regarding the structure of something e.g. what it should look like, as being a design message. Several of those who did consider suggestions as being design messages had difficulty classifying them according to my scheme.

Another failure of the design question became apparent during interviews with respondents: some design situations exist in which the designer does not receive a message from someone else relating to what is to be designed. A separate section should have been included in the questionnaire similar to part (b) but excluding the 'message received' boxes.

The situations 'no messages received' and 'messages produced' are included in part (b), but if a person involved in those situations also receives messages in other situations, then from the present form of Q.14 there is no way of determining if he is involved in the former class of situations. The only way to determine this is by a separate question; which would also make the questionnaire easier to answer (some of the respondents told me they were not sure how to answer (b) because of this factor).(1)

Excluding the points mentioned above the interviews indicated the respondents had interpreted the questionnaire as intended. I believe consistent interpretation can be obtained in all surveys using questionnaires provided the concepts used are carefully defined.

(1) *Footnote: I believe the personality function required to design competently is the same for the situations in which messages are received from someone else and those in which they are not. For this reason the omission was not critical.*

10.4 TECHNICAL MANPOWER ADAPTATION : A COMMENT

The approach described for the survey is cross-sectional. It produces static models : technical jobs are assumed to remain fixed. They are classified so that the personality functions necessary to perform them efficiently can be determined. This approach was requested by the Technical Manpower Training Committee. At the time, I considered it to be a sound approach.

Since the survey my views have changed radically, for two reasons:

(1) Most of those interviewed during the survey stressed the changing character of their jobs. They considered the dynamic aspect to be the most important in relation to their work.

(2) I have an increased understanding of systems concepts. Organisations are open systems. As such they can achieve the same end state from different initial conditions and in different ways. Hence, knowledge of a given state is insufficient to predict later states : knowledge and understanding of the way the system behaves is also required. The cross-sectional approach is inadequate for this reason.

I now believe the most fruitful way to model technical manpower is by considering their dynamic characteristics i.e. their adaptability. The next chapter presents some of my thoughts on this topic.

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CHAPTER 11

TECHNICAL MANPOWER ADAPTATION

11.1 INTRODUCTION

The results from the survey indicated there was no significant difference in the relative frequencies of the tasks performed by the two engineering classes - professional engineers and technicians. During interviews professional engineers maintained that a considerable portion of their work could be performed by technicians.

Professor McCallion and the author observed that industry utilizes the two classes of engineers to perform a wide variety of functions which are similar for the two classes. Our discussions with engineers in industry led us to believe the most important criterion for selecting engineers is their 'adaptability'. This hypothesis was supported by the fact that companies appear to be using the educational system as an intelligence filter.

I believe there are two types of adaptability which are important to companies with regard to manpower planning:

(1) adaptability an individual needs to learn his job;

(2) adaptability required of an individual when he is competent in his job.

I shall discuss the first type briefly because it is the least important.

Assuming the requirements for a particular job have been identified, it is still necessary to determine the entry qualifications for someone starting the job and the training programme to bring him to the desired level of efficiency. As technical personnel are selected according to the second criterion above (and they should be of course) the individual's capacity to learn his job is fixed. Hence, the time-period for training will depend on the individ-

ual's entry state and the efficiency of the training programme.

From the educationalists' point of view a fruitful approach to the training problem is to determine the time-periods companies can afford to release their staff for training. The time-periods and the job specifications provide a basis for determining the qualifications individuals need to enter industry, the kinds of training programmes industry requires, and the desired levels of efficiency of such programmes.

My observation is that small companies cannot sustain staff for long training periods - my estimate is ½ - 1 yr maximum - so they tend to select experienced tradesmen, N.Z.C. qualified technicians, and/or experienced graduates. Large companies can afford relatively long training periods - typically 3 - 5 yrs maximum. They employ inexperienced as well as experienced personnel.

The implication of this approach for the N.Z. Government (particularly the Vocational Training Council) is it highlights the problem areas and indicates the alternative courses of action available. For example: companies may be induced to release staff for longer training time-periods by financial assistance from the Government e.g. tax relief. Educational programmes may be better designed to suit the needs of industry. The efficiencies of training programmes may be increased to reduce the time in training,

The remainder of the chapter is concerned with the adaptability an individual requires to be competent in his job. The appropriate mode of adaptability is shown to depend on the causal texture of the environment by considering the relationships between environmental complexity and technical manpower instrumentality (use of, search for and development of instruments), planning and modelling.

Emery and Trist (1975) have identified four levels of causal texturing of the environment. These are, in order of increasing complexity : placid random, placid clustered, disturbed reactive and turbulent environments. I shall show it is possible to classify technical staff according to these environmental levels.

Finally, I draw some tentative conclusions regarding the importance of the different levels of technical personnel for New Zealand industry.

11.2 INSTRUMENTALITY AND ENVIRONMENTAL LEVELS

Emery and Trist (1975) give an indication of the instrument-making capabilities of the different types of adaptive individuals. It is important to distinguish between using, searching for and developing (designing) instruments because these are different activities.

Fig. 11.1 shows the types of individuals adaptive to each level of environment and the instruments the individuals can use or design. This is my formulation of the work by Emery and Trist.

Two points should be noted:

(1) I have extended my definition of design to include goal-seeking systems as designers. The minimum requirement for a system to be able to design is it must have a choice of action.

(2) Ideal - seeking systems can use objective-seeking systems as instruments by constraining the range of objectives they can pursue.

11.3 PLANNING AND ENVIRONMENTAL LEVELS

The planning behaviors appropriate for the different levels of environment have been identified by Emery and Trist (1975). Detail descriptions of each type of behavior are given by Ackoff (1972).

The placid random environment requires no planning - one simply does the best one can under the circumstances.

'Satisficing' is the planning mode appropriate for placid clustered environments. Ackoff (1972, p.64) provides this description of satisficing: *...the planning process begins with the setting of goals which are believed (though seldom demonstrated) to be both feasible and desirable. Attribution of these properties to the goals is usually based on consensus among the planners. Once these goals are set - and they are usually set independently of other aspects of planning - operating policies are sought which will hopefully attain the goals and are acceptable both to management and to the people who must carry them out.*

Emery and Trist point out some of the planning approximations appropriate for this type of environment. These are: domain selection, the development of a hierarchy of strategies, the assignment of step functions to the values of goals and noxiants, and the backward determination of the strategic path.

The disturbed reactive environment requires 'optimizing' planning:

In this second type of planning the setting of goals and the selection of operating policies interact with one another; an effort is made not to do just well enough, but to do as well as possible....It calls for the development of mathematical models of the system being planned for - models that can be analyzed or simulated to determine the effect of different policies and resource allocations on organization performance [Ackoff (1972, p.65)].

With this pattern of planning organisation structure is seldom explicitly treated. Furthermore, optimization can be used to develop a control system to be added to the system but it cannot provide a control unit that is built into the system.

The highest level of environment (turbulent) requires 'adaptive' planning. Ackoff (1972) describes this as follows:

Adaptive planning...should not only build into the system controls which protect against major and relatively stable changes in it and its environment; it should also build adaptiveness into the components of the system, so that short-run variations can either be more adequately handled or reduced.

If a completely adaptive system could be designed, it would require no planning. To the extent that adaptive planning succeeds, therefore, the need for planning is reduced. The ultimate ideal of the adaptive planner is a system for which planning is no longer necessary (p.68-69).

It can be seen that each level of environment requires a different planning mode and the abilities required of the planner become more demanding as environmental level increases.

From my brief observation of New Zealand industry during the EITB survey, most companies appear to be 'satisficing' planners, while a few large ones may be 'optimizers'. There are no 'adaptivizers'.

11.4 MODELLING AND ENVIRONMENTAL LEVELS

Modelling is one of the most important aspects of technical manpower adaptation. Adaptation involves choice, and choice of a course of action presupposes the decision maker has a model of his choice situation. An individual's model of his choice situation is his representation of it.

The degree of complexity of a choice model depends on three main factors: the accuracy desired in the outcomes, the limits within which the essential variables of the system must be maintained and the causal texture of the environment.

11.4.1 Accuracy Desired in Outcomes and Tolerance Limits of Essential Variables.

The outcomes in a choice situation may be defined broadly or narrowly. The more narrowly these are defined the more narrowly the courses of action must be defined and the more accurate must be the estimation of the relevant environmental factors and the parameters of the situation. The choice model becomes more complex.

In any choice situation there will always be constraints. Some of these relate to the essential variables of the decision maker or the system of which he is an element. A decrease in the range of values which these variables may take without destroying the viability of the system will increase the complexity of the choice model.

11.4.2 Causal Texture of the Environment

The complexity of the environment increases as the level of environment goes from placid random to turbulent, consequently the choice model must become more complex.

The individual enters his choice situation with a model of it. If he is dissatisfied with his initial model he will modify it until it is acceptable. The degree of correspondence between the final and initial models can vary: from isomorphism to extreme homomorphism. An interesting investigation would be to determine the effect of environmental level on the degree of correspondence between the final and initial models. My opinion is there would be a high degree of correspondence for the placid environments but a low degree of correspondence for the dynamic environments.

The individual will, in general, not be conscious of every aspect of his choice model. It can be divided into two sub-models : an explicit model - those aspects he is conscious of, and an implicit model - those aspects he is not conscious of. Furthermore, his inferences can be similarly classified into those which are conscious (thought) and those which are unconscious (intuition).

Technical personnel, through education, are taught explicit models and explicitly formulated inferential procedures. It is part of their job to use these in their modelling or decision-making if they are relevant. The degree to which they should be used, however, depends on many factors e.g. the time-period to make a decision, the cost of quantifying the model and adjusting it to the particular situation, the cost of errors, etc.

Explicit models and inferential procedures can also be developed by an individual if he has been trained by experience and reflects on his past behavior. Implicit models and procedures are developed by experience.

Beer (1972, Chapter 14) has produced a method to measure the variety of a choice situation. I believe his method can be adapted to:

(1) measure the effectiveness of existing explicit models and inferential procedures in a given situation;

(2) determine the best cost effective ratio of the amount of education to the amount of training by experience in a training programme.

Beer's method can be used directly to measure the decision-making performance of management teams e.g. planning teams; he developed the method to monitor the progress of top management decision-making. Some problems will be encountered using it to measure the performance of design teams because of the difficulty of measuring the variety of the situation.

His method can be used to measure the effectiveness of existing explicit models and inferential procedures. The variety of the actual situation, the variety of a model, and the variety reduction produced by an inferential procedure can be determined using his method. Comparison of the model variety to that of the actual situation gives a measure of the homomorphism of the model. For an excellent discussion of this aspect of modelling refer to Beer (1966, Chapter 6).

Given the degree of homomorphism of the model and a cost function a measure of the effectiveness of the model can be produced. Similar comments apply to explicit inferential procedures.

Finally, consider the application of Beer's method for developing training programmes. Let us assume the effectiveness of an existing explicit model and inferential procedure in a situation has been measured. If this is acceptable then the training programme should emphasize education, (i.e. the trainee is taught the explicit model or procedure for that situation); no or little training by experience is required.

If the model is unacceptable it will have to be developed until a satisfactory degree of homomorphism with reality is attained. The remainder of the model may be:

(1) implicit. This requires training the trainee by experience;

(2) explicit. Research would have to be conducted to develop the model explicitly. Ths final model would be taught by education;

(3) a combination of (1) and (2).

It should be clear by now that Beer's method provides a basis for objectively modelling technical manpower, monitoring the performance of technical teams, and designing training programmes. Furthermore, it highlights a significant fact: extending an explicit model by research and teaching this final model by education is an ALTERNATIVE to training by experience, and vice versa.

A by-product of Beer's method is it could also be used to identify which decisions should be programmed (e.g. on a computer) and which should be made by technical staff.

I would expect environmental level to have a significant effect on the performance of technical teams and the design of training programmes.

The degree of complexity of the environment and the system being studied in a scientific investigation has a significant effect on the methods which scientists should use. Ashby (1958, p.98) says:

What I suggest is that measurement of the quantity of information, even if it can be done only approximately, will tell the investigator where a complex system falls in relation to his limitation. If it is well below the limit, the classic methods may be appropriate, but should it be above the limit, then if his work is to be realistic and successful, he must alter his strategy to one more like that of operational research.

Emery and Trist (1975) go further and state that domain-based problem-oriented research is the appropriate scientific approach for turbulent environments.

11.5 SUMMARY

The causal texture of the environment has been shown to affect significantly the mode of adaptation of technical personnel. I consider it to be the most important factor affecting technical manpower adaptability. Rigorous definitions of the environmental levels are required so they can be explicitly recognized in actual situations.

Technical staff can be classified according to the environmental level to which they adapt: there are four levels.

Emery and Trist (1975) observe that turbulent fields are becoming more salient both for industrialized countries moving to post-industrialism and pre-industrial countries moving to industrialism. If the principle of redundancy of functions is accepted by these countries as a design strategy then we can expect a shift in education and training towards developing those abilities of technical personnel which are adaptive to turbulent environments.

I believe the higher levels of technical manpower are essential for New Zealand industry. Industry should be moving towards optimizing and adaptivizing planning. Scientists should be moving towards operational research and domain-based inquiry.

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CHAPTER 12

CONCLUSION : THE COMBINED THESIS

THESIS I

THE NATURE OF THE TECHNICAL MANPOWER PROBLEM

(Reference : Chapter 2, p. 5)

The technical manpower problem is: how do the New Zealand Government and management of companies in New Zealand industry control the movement of technically qualified people into, within, and out of the industry and design new organisations so that the companies and industry adapt successfully to their environments?

Inquiry of this problem requires domain-based problem-oriented research.

THESIS II

THE RESEARCH PROJECT

(Reference : Chapter 3, p. 16)

Domain-based inquiry of the technical manpower problem will aim to produce a symbolic model of the situation.

The following behaviors will be essential elements of this model: designing, planning, leading, organising, and managing. These must be defined if the model is to take on meaning.

The most useful definitions will be idealized operational definitions because they provide a scientific standard for all researchers, regardless of their orientation. Production of these definitions will be a suitable research project for a Ph.D. thesis.

THESIS III

DEFINITION OF DESIGNING

(Reference : Chapter 5, p.26)

A purposeful individual (A) designs, if in a choice environment S in a time-period $t_1 - t_2$:

(1) A produces a message M_1 connoting two or more essential properties $\{p_x\}$ of a concrete system(s) or object(s), which does not exist in any environment at time t_1;

(2) the message (M_1) is a potential producer of at least one essential structural property of the system(s) or object(s) in some environment S_j;

(3) at time t_1, A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ in S such that the union of $\{p_1\}$ and $\{p_s\}$ exhausts $\{p_x\}$.

The set of properties $\{p_x\}$ is the design.

THESIS IV

DEFINITION OF PLANNING

(Reference : Chapter 6, p.41)

wishful projection: a message connoting an end(s), goal(s), objective(s) or ideal(s), or some combination of these.

reference projection: a message connoting an expected environment of a purposeful (or goal-seeking) system and the course(s) of action (choice(s)) of the system in that environment when the system does not expect it.

A purposeful individual (A) plans, if in a choice environment S in a time-period $t_1 - t_2$:

(1) A produces a message M_1 connoting two or more essential properties $\{p_x\}$ of an available course(s) of action (choice(s)) of another individual (goal-seeking system) C, that exists at time t_1, in a choice environment S_j at t_j for C to produce an outcome O_k at t_k ($t_k > t_j > t_2$);

(2) the message (M_1) is a potential producer of O_k;

(3) at time t_1, A is not aware of the complete set of properties $\{p_x\}$ but is aware of a sub-set $\{p_1\}$;

(4) the sub-set $\{p_1\}$ must include the essential properties of a wishful projection and a reference projection for C;

(5) during time-period $t_1 - t_2$, A does not perceive a set of properties $\{p_s\}$ in S such that the union of $\{p_1\}$ and $\{p_s\}$ exhausts $\{p_x\}$.

The set of properties $\{p_x\}$ is the plan.

THESIS V

DEFINITION OF LEADERSHIP

(Reference : Chapter 7, p. 52)

There are three kinds of leadership: outcome-directed leadership, means-directed leadership (familiarization) and symbolic leadership (a combination of the first two).

Outcome-directed leadership (O-leadership): one purposeful individual (A) has O-leadership over another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's relative value for O_j.

Amount of O-leadership: the amount of O-leadership an individual (A) has over another (B), in an intention situation, for an outcome (O_j) for which $V_{j_A} = 1.0$ and $V_{j_{B_1}} = 0.0$ relative to an exclusive and exhaustive set of outcomes $\{O_j\}_B$ in a choice environment S is the increase in B's relative value for O_j produced by A.

$$L_{j_{AB}} = ((V_{j_{B_2}} - V_{j_{B_1}}) \mid V_{j_A} = 1.0,\ V_{j_{B_1}} = 0.0,\ S,\ \{O_j\}_B)$$

O-leadership function: A's O-leadership function for an individual (B) and an outcome (O_j) relative to a set of outcomes $\{O_j\}_B$ in an environment S is a mathematical function (f_L) that satisfies the equation

$$L_{j_{AB}} = f_L(V_{j_A},\ EV_{B_1},\ \{E_{ij}\}_{B_2},\ \{DF_{ij}\}_{B_2},\ \{DK_{ij}\}_{B_2},\ \{DU_{ij}\}_{B_2} \mid S,\ \{O_j\}_B)$$

Generalized O-leadership function: A's generalized O-leadership function for an individual (B) and an outcome (O_j) is the mathematical function (f^*_L) that satisfies the equation

$$L_{j_{AB}} = f^*_L(V_{j_A}, EV_{B_1}, \{E_{ij}\}_{B_2}, \{DF_{ij}\}_{B_2}, \{DK_{ij}\}_{B_2}, \{DU_{ij}\}_{B_2}, S|\{O_j\}_B)$$

Familiarization (means-directed leadership): one purposeful individual (A) familiarizes another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, with a course of action (C_i), which has an efficiency greater than zero for O_j, when A intentionally produces an increase in B's degree of familiarity with C_i.

Amount of familiarization: the amount of familiarization an individual (A) has for another (B), in a familiarity situation, and a course of action (C_i) relative to an exclusive and exhaustive set of courses of action $\{C_i\}_B$, an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, $L(E_{ij})_{B_1} = L(E_{ij})_{B_2} = 1.0$, and $P_{i_{B_1}} = 0.0$ is the increase in B's probability of choosing C_i produced by A.

$$Fa_{ij_{AB}} = ((P_{i_{B_2}} - P_{i_{B_1}})|V_{j_A} = 1.0, V_{j_{B_1}} = V_{j_{B_2}} = 1.0, L(E_{ij})_{B_1} = L(E_{ij})_{B_2} = 1.0, P_{i_{B_1}} = 0.0, \{C_i\}_B)$$

Familiarization function: A's familiarization function for another individual (B) and a course of action (C_i) relative to an outcome (O_j) and an available set of courses of action $\{C_i\}_B$ is the mathematical function (f_{Fa}) that satisfies the equation

$$Fa_{ij_{AB}} = f_{Fa}(V_{j_A}, EV_{B_1}, V_{j_{B_2}}, L(E_{ij})_{B_2}|\{C_i\}_B)$$

THESIS VI

DEFINITION OF ORGANISING

(Reference : Chapter 8, p. 72)

There are two kinds of organising: Knowledge-organising and Understanding-organising.

Knowledge-organising (K-organising): one purposeful individual (A) K-organises another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's degree of knowledge of a course of action (C_i) which has an efficiency greater than zero for O_j.

Amount of K-organising: the amount of K-organising an individual (A) has over another (B), in a knowledge situation, for a course of action (C_i) relative to an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, and $DK_{ij_{B_1}} = 0.0$ in a choice environment S is the increase in B's degree of knowledge produced by A.

$$o^K_{ij_{AB}} = ((DK_{ij_{B_2}} - DK_{ij_{B_1}}) \mid V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ DK_{ij_{B_1}} = 0.0,\ S)$$

K-organising function: A's K-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) in a choice environment S is a mathematical function (f^K_o) that satisfies the equation

$$o^K_{ij_{AB}} = f^K_o\ (V_{j_A}\ ,\ EV_{B_1}\ ,\ V_{j_{B_2}} \mid S)$$

Generalized K-organising function: A's generalized K-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) is a mathematical function (f^{K*}_o) that satisfies the equation

$$O^{K}_{ij_{AB}} = f^{K*}_{o}(V_{j_A}, EV_{B_1}, V_{j_{B_2}}, S)$$

Understanding-organising (U-organising): one purposeful individual (A) U-organises another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's degree of understanding of a course of action (C_i) which has an efficiency greater than zero for O_j.

Amount of U-organising: the amount of U-organising an individual (A) has over another (B), in an understanding situation, for a course of action (C_i) relative to an outcome (O_j), $V_{j_A} = 1.0$, $V_{j_{B_1}} = V_{j_{B_2}} = 1.0$, $DU_{ij_{B_1}} = 0.0$ with respect to a state variable (s) in an environment (S') is the increase in B's degree of understanding of C_i produced by A.

$$O^{U}_{ij_{AB}} = ((DU_{ij_{B_2}} - DU_{ij_{B_1}}) \mid V_{j_A} = 1.0, V_{j_{B_1}} = V_{j_{B_2}} = 1.0, DU_{ij_{B_1}} = 0.0, s, S')$$

U-organising function: A's U-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) and a state variable (s) in an environment (S') is a mathematical function (f^{U}_{o}) that satisfies the equation

$$O^{U}_{ij_{AB}} = f^{U}_{o}(V_{j_A}, EV_{B_1}, V_{j_{B_2}} \mid s, S')$$

Generalized U-organising function: A's generalized U-organising function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) is a mathematical function (f^{U*}_{o}) that satisfies the equation

$$O^{U}_{ij_{AB}} = f^{U*}_{o}(V_{j_A}, EV_{B_1}, V_{j_{B_2}}, s, S')$$

THESIS VII

DEFINITION OF ACQUAINTANCE

(Reference : Chapter 8, p.72; and Chapter 7, p.52)

Acquaintance: one purposeful individual (A) acquaints another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, with a course of action (C_i), which has an efficiency greater than zero for O_j, when A intentionally produces an increase in B's degree of belief in the maximum relative efficiency of C_i for O_j

Amount of Acquaintance: the amount of acquaintance an individual (A) has with another (B), in a belief situation, and a course of action (C_i) relative to an exclusive and exhaustive set of courses of action $\{C_i\}_B$, an outcome (O_j),

$$V_{j_A} = 1.0,\ V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ P_{i_{B_1}} = 0.0,\ L(DI_i)_{B_1} = L(DI_i)_{B_2} = 1.0$$

is the increase in B's probability of choosing C_i produced by A.

$$A_{ij_{AB}} = ((P_{i_{B_2}} - P_{i_{B_1}}) \mid V_{j_A} = 1.0, V_{j_{B_1}} = V_{j_{B_2}} = 1.0,\ L(DI_i)_{B_1} = L(DI_i)_{B_2} = 1.0,\ P_{i_{B_1}} = 0.0,\ \{C_i\}_B)$$

Acquaintance function: A's acquaintance function for an individual (B) and a course of action (C_i) relative to an outcome (O_j) and an available set of courses of action $\{C_i\}_B$ is a mathematical function (f_A) that satisfies the equation

$$A_{ij_{AB}} = f_A(V_{j_A},\ EV_{B_1},\ V_{j_{B_2}},\ L(DI_i)_{B_2} \mid \{C_i\}_B)$$

THESIS VIII

DEFINITION OF MANAGING

(Reference : Chapter 9, p.85)

Management: one purposeful individual (A) manages another individual (B), that is an actual or potential producer of an outcome (O_j) preferred by A, when A intentionally produces an increase in B's expected value for O_j.

Amount of management: the amount of management an individual (A) has over another (B) relative to an outcome (O_j), $V_{j_A} = 1.0$ and $EV_{j_{B_1}} = 0.0$ in a choice environment S is the increase in B's expected value for O_j produced by A.

$$M_{j_{AB}} = ((EV_{j_{B_2}} - EV_{j_{B_1}}) \mid V_{j_A} = 1.0,\ EV_{j_{B_1}} = 0.0,\ S)$$

Management function: A's management function for an individual (B) relative to an outcome (O_j) in an environment S is the mathematical function (f_m) that satisfies the equation

$$M_{j_{AB}} = f_m\ (V_{j_A}\ ,\ EV_{B_1} \mid S)$$

Generalized management function: A's generalized management function for an individual (B) relative to an outcome (O_j) is the mathematical function (f_m^*) that satisfies the equation

$$M_{j_{AB}} = f_m^*\ (V_{j_A}\ ,\ EV_{B_1}\ ,\ S)$$

A P P E N D I C E S

APPENDICES 1 - 5 : BIBLIOGRAPHY

The bibliography is presented in an edited form.

Authors where works are referred to in the main text are fully referenced.

Authors whose works have been surveyed, but who are not referred to in the text, are indicated by an alphabetical list of their names. Where there was more than one author for a book or article each co-author is listed.

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Albers H
Alford L P
Allen L A
Athos A G
Barnes S H
Batty J
Bavelas A
Beatty H R
Berliner W H
Blanchard K H
Bowers D G
Brech E F
Broom H N
Brown R G
Byars L I
Campbell D
Carlisle H M
Champion D J
Clifford C
Coffey R E
Cohn T S
Converse P E
Coons A E
Cooper J B
Dale E
Davis K L
Doktor R H
Drake R I
Drucker P F
Duncan W J
Fearn D A
Fleishman E A
Foerst J R
Follett M P
Foster R
Fulmer R M
George C S
Gibb C A
Gordon T
Graham G H
Greenlaw P S
Groff G K
Gross B
Gutenberg A W
Haberstroh C J
Haiman T
Haire M
Hall R H
Halpin A W
Hammond W R
Hardwick C T
Hargrove E C
Harris E F
Hawkins H
Haynes W W
Hemphill J R
Hersey P
Hodge B J
Hodges H G
Hoffman S
Hollander E P
Hostiuck K T
House R J
Hudson C C
Hunt J W
Hutton G
Johnson H J
Jones H R
Jones M H
Kazmier C J
Keller S
Kirscht J P
Knickerbocker J
Landuyt B F
Lassey W R
Lasswell H D
Lazarus H
Likert R
Lippitt G L
Litterer J A
Lodahl T M
Longenecker J G
Lowry R P
McFarland D E
McGaugh J L
McGuire J W
McLarney W J
Maier N R F
Massarik F

Massie J L
Mescom M H
Michael S R
Mockler R J
Moment D
Field-Marshall Viscount Montgomery of Alamein
Moore F G
Moses M A
Mott P
Muth J F
Newcomb T M
Newman W H
Ogden R
Petrullo L
Ready R K
Richards M D
Richman E
Rose A M
Rubenstein
Rush C H
Schnee J E
Scott W
Seashore S E
Seligman L G
Selznick P
Sisk H L
Smith P J
Spotts J V
Starr M K
Summer C E
Tannenbaum R
Tead O
Terry G R
Torgerson P E
Vance S
Wagner L W
Wall R G
Wallace M J
Warren E K
Weinstock I T
Weschler I K
Wilkinson E
Zaleznik A
Zeigler R J

APPENDIX 4

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Dale E
Davis R C
Deverell C S
Donnelly J H
Duncan W J
Flippo E B
Foster R S
Fulmer R M
George C S
Gibson J L
Gross B M
Haiman T
Hicks H G
Hodge B J
Hodges H G
Hof R T
Hostiuck R T
Hulley O S
Ivancevich J M
Johnson H J
Kazmier L J
Longenecker J G
Massie J L
Mee J F
Newman W H
Ritchey J A
Scott W G
Sisk H L
Summer C E
Terry G R
Wickesberg A K
Wilkinson E
Zeigler R J

APPENDIX 5

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Deverell C S
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Doktor R H
Donnelly J H
Drucker P F
Farmer R N
Fayol H

Fish L
Flippo E B
Foerst J R
Foster R S
French W
George C S
Gibson J L
Graham G H
Greenwood W T
Gross B M
Gulick L
Gutenberg A W
Haiman T
Hammond W R
Harbison F
Hicks H G
Hodge B J
Hodges H G
Hodgetts R M
Hof R T
Hostiuck K T
Hulley O S
Hunt J W
Hutton G
Ivancevich J M
Jacques W
Johnson H J
Johnson R A
Jones T R
Kast F E
Katz R L
Kazmier L J
Kimball D S
Leeds C A
Lehrer R N
Likert R
Litterer J A
Longenecker J G
McFarland D E
McGregor D
Marshall A
Massie J L
Mee J F
Mescom M H
Meyers C A
Miles R E
Miner J B
Mooney J D
Moses M A
Nelson T H
Neuhauser D
Newman W H
O'Donnell C
Parker H
Paterson T T
Peterson E
Plowman E G
Reiley A C
Richman E
Ritchey J A
Rosenzweig J E
Sayles L R
Scanlan B H
Scott W G
Sheldon O
Simon H A
Skertchly A R B
Smiddy H F
Smith A
Stainton R S
Starr M K
Summer C E
Taylor F W
Terry G
Tilles S
Voich D
Wadia M S
Wickesberg A K
Wilkinson E
Wren D A
Zeigler R J

EITB
ENGINEERING INDUSTRY TRAINING BOARD

APPENDIX 6

PERSONAL QUESTIONNAIRE FROM EITB SURVEY

September 1977

A Survey of Knowledge used and Tasks performed
by qualified scientists and engineers in New Zealand
Manufacturing and Processing Firms

This questionnaire is part of our industry-wide survey, in which your firm has agreed to take part. All answers will be regarded as confidential and used for research purposes only.

The survey was initiated because Members of the Engineering Industry Training Board wished to have a cross-sectional view of the knowledge used and tasks performed by qualified scientists and engineers, to assist them in advising the Vocational Training Council and other bodies on the education and training needs of the industry, and in deciding what, if any, new training schemes they should plan and develop.

A sample of the people who complete this questionnaire will be approached for a personal interview of approximately ½ hour duration.

Would you be willing to be interviewed?

Yes ☐ No ☐

Please return the completed questionnaire to:

Senior Training Adviser,
Engineering Industry Training Board,
Durham House,
Durham Lane,
Auckland.

by 7 days after receiving it.

If for some reason you are unable to or do not wish to fill in the questionnaire, please return it with a line through this page for record keeping purposes.

Thank you for your time and assistance.

H. McCALLION
Board Member

SECTION 1 - GENERAL

Q.1 Name of firm .....

Q.2 Address of your place of work

.....

Q.3 What is your present job title?

.....

Q.4 How long have you been employed in your present position?

..... years ..... months

Q.5 How many years of industrial experience have you had since you completed your formal education?

..... years

Q.6 What is the job title of your immediate superior?

.....

Q.7 Professional and Academic Experience

(a) Are you a Corporate Member (i.e. a Fellow or a full Member) of a professional engineering institution?

If your answer is NO, please tick NO box and follow arrow. If your answer is YES, please tick the boxes corresponding to those institutions of which you are a member. Please leave boxes blank if they do not apply to you. (Note: if your answer is YES you must tick at least one box).

	Yes, a Fellow or a Full Member of	
1		The Royal Aeronautical Society
2		The Institution of Chemical Engineers
3		The Institution of Civil Engineers
4		The Institution of Electrical Engineers
5		The Institution of Electronic and Radio Engineers
6		The Institute of Fuel
7		The Institute of Marine Engineers
8		The Institution of Mechanical Engineers
9		The Institution of Mining and Metallurgy
10		The Institution of Production Engineers
11		The Institution of Structural Engineers
12		The New Zealand Institution of Engineers
13		The Institution of Engineers (Australia)
14		Others (please specify Institutions)
		.....

No ☐ → *Please go to (b)*

(b) Are you a Registered Engineer or a Registered Engineering Associate?

	Yes	
1		a Registered Engineer
2		a Registered Engineering Associate

No ☐ → *go to (c)*

(c) Do you have a University Bachelor's Degree in Engineering or Science?

	Yes	*(please tick relevant boxes)*
1		B.E. (Mechanical)
2		B.E. (Electrical)
3		B.E. (Civil)
4		B.E. (Chemical)
5		B.Sc.
6		M.E. or M.Sc.
7		Ph.D. in Engineering or Science
8		Other (please specify degree type)

.....

.....

No ☐ → *go to (d)*

(d) Do you have any of the following qualifications?

	Yes	
1		A New Zealand Certificate in Draughting?
2		A New Zealand Certificate in Engineering?
3		A New Zealand Certificate in Science?

No ☐ → *go to (e)*

(e) Do you have any of the following United Kingdom qualifications?

	Yes	*(please tick relevant boxes)*
1		Higher National Certificate in Engineering
2		Higher National Certificate in Science
3		Higher National Diploma in Engineering
4		Higher National Diploma in Science

No ☐ → *go to (f)*

(f) Do you have other technical qualifications?

Yes
Please specify .....
.....

No ☐ → *Go to Section 2*

SECTION 2 - KNOWLEDGE REQUIREMENTS

This section is intended to identify the areas of knowledge you require, to be competent in your present job. To assist you to answer this section, we provide the following definitions:

To be able to select an efficient procedure involves having an appreciation of the procedures or actions which can lead to a particular result.

To be able to perform a procedure involves knowing how to execute it.

To perform a procedure with skill means being able to execute it with precision and certainty.

To have an appreciation of an area of knowledge involves knowing its relevance to your work.

To be able to use an area of knowledge involves knowing how to apply it in practice.

To use an area of knowledge with skill means being able to apply it in practice with precision and certainty.

Q.8 Knowledge of Subjects and Procedures

Please indicate the procedures/areas of knowledge which you require, to be competent in your present job, by ticking the relevant boxes below. Those procedures/areas of knowledge you require, but which are not listed, should be included by writing them in under the appropriate main heading. Not all the procedures/areas of knowledge will apply to you, where this is so please leave boxes blank.

	I perform/use this procedure/area of knowledge with skill in my present job	I have to know how to perform/use this procedure/area of knowledge to be competent in my present job	I need an appreciation of this procedure/area of knowledge to be competent in my present job	
1				BASIC SCIENCE
1.01				Physical or General Chemistry
1.02				Organic Chemistry
1.03				Inorganic Chemistry
1.04				Electrochemistry
1.05				Biochemistry
1.06				Physics
1.07				Biology
1.08				Geology/Soil Mechanics
1.09				General system theory
				Other (please specify):
1.10	—	—	—	.....
1.11				.....

Question 8 Continued

	I perform/use this procedure/area of knowledge with skill in my present job	I have to know how to perform/use this procedure/area of knowledge to be competent in my present job	I need an appreciation of this procedure/area of knowledge to be competent in my present job	
2				MATHEMATICS
2.01				Algebra
2.02				Geometry
2.03				Trigonometry
2.04				Calculus/Differential Equations
2.05				Complex Variable Theory
2.06				Statistics/probability theory
2.07				Curve fitting of time series
2.08				Vector analysis
2.09				Numerical methods/Difference Equations
2.10				Computer languages (e.g. Algol, Cobol, Fortran, Assembler, Basic)
				Other (please specify):
2.11	—	—	—	.....
2.12				.....
3				APPLIED SCIENCE AND ENGINEERING
3.01				Mechanics/Structures
3.02				Thermodynamics
3.03				Heat transfer
3.04				Mass transfer
3.05				Fluid mechanics
3.06				Applied pneumatics
3.07				Oil-hydraulic systems
3.08				Fuel technology
3.09				Chemical kinetics
3.10				Communication technology
3.11				Electrical power generation, transmission and/or distribution
3.12				Electrical power utilization - electrical machines, electric circuits, etc.
3.13				Electronics (industrial, medical etc.)
3.14				Control system theory
3.15				Cybernetics
3.16				Optimisation theory (linear programming, dynamic programming etc.)
3.17				Simulation theory/Computer simulation
3.18				Queueing theory/Inventory theory

Question 8 Continued

	I perform/use this procedure/area of knowledge with skill in my present job	I have to know how to perform/use this procedure/area of knowledge to be competent in my present job	I need an appreciation of this procedure/area of knowledge to be competent in my present job	
				APPLIED SCIENCE AND ENGINEERING (Continued)
3.19				Replacement theory
3.20				Reliability theory
3.21				Point, trace or outcome forecasting, e.g. prediction of future prices, delivery dates, etc.
3.22				Technological forecasting, event forecasting.
3.23				Network planning procedures/Resource allocation procedures
3.24				Work study
3.25				Ergonomics
3.26				Environmental science
3.27				Computer systems
				Other (please specify):
3.28				.....
3.29	—	—	—	.....

4				ADMINISTRATION AND MANAGEMENT
4.01				Economics
4.02				Accounting'
4.03				Cost estimating procedures
4.04				Discounted cash flow procedures
4.05				Planning procedures
4.06				Organising procedures
4.07				Controlling procedures
4.08				Foreign language(s) (please specify): .....
4.09				Personnel management (those aspects of managing concerned with the recruitment, selection, training, promotion, remuneration or working conditions of company personnel)
4.10				Industrial relations
4.11				Contract Administration
				Other (please specify):
4.12	—	—	—	.....
4.13				.....

Question 8 Continued

	I perform/use this procedure/area of knowledge with skill in my present job	I have to know how to perform/use this procedure/area of knowledge to be competent in my present job	I need an appreciation of this procedure/area of knowledge to be competent in my present job	
5				MARKETING
5.01				Advertising
5.02				Marketing research
5.03				New product management
5.04				Packaging (for market)
5.05				Physical distribution management
5.06				After sales service
5.07				Pricing
				Other (please specify):
5.08	—	—	—	.....
5.09				.....

6				LEGAL REQUIREMENTS
6.01				Commercial law (relates to the sale and transfer of goods)
6.02				Company law (relates to companies and partnerships)
6.03				Industrial law (relates to contracts of employment, arbitration, conciliation, etc.)
6.04				Patent law
				Others (please specify):
6.05	—	—	—	.....
6.06				.....

7				ANY SUBJECT NOT COVERED BY ABOVE HEADINGS
				Please specify any subjects which are important for your present job but which are not covered by the headings above
7.01	—	—	—	.....
7.02	—	—	—	.....
7.03	—	—	—	.....
7.04	—	—	—	.....
7.05				.....

Q.9 Knowledge of Processes/Operations

Do you perform, have to know how to perform, or need an appreciation of the following processes?

NO ☐ *go to Section 3*

YES ☐ *Please tick relevant boxes*

	I perform this process with skill in my present job	I have to know how to perform this process to be competent in my present job	I need an appreciation of this process to be competent in my present job	
1				Casting processes, e.g. sand moulding, die casting
2				Forming processes, e.g. hot forging, drop stamping, metal pressing processes, wire drawing
3				Joining processes, e.g. gas or electric welding, soldering, brazing, riveting
4				Machining processes, e.g. turning, milling, spark erosion, ultrasonic, electrolytic
5				Material treatment processes, e.g. heat treatment, protective coating, metal finishing
6				Automated assembling processes
7				Automated processes, e.g. NC machines
8				Electronic circuit assembly and wiring
9				Printed circuit production
10				Production of thermionic devices
11				Non-destructive testing
12				Compression or transfer moulding of thermosetting plastics
13				Extrusion or injection moulding of thermoplastics
14				Blow moulding or vacuum forming of thermoplastics
15				Corrosion processes
16				Electrochemical operations
17				Drying processes
18				Combustion processes
19				Fuel conversion processes, e.g. gas making
20				Separation processes, e.g. gas absorption, liquid extraction, distillation
21				Air pollution control
22				Water or effluent treatment
				Other (please specify):
23				.....
24	—	—	—	.....

SECTION 3 - TASKS

In this section we hope to find the range of tasks you perform in your job.

PART A.

Q.10 Communication Task

DEFINITION: The production of messages which will inform, instruct or motivate the receivers of your messages as you intend.

(a) As part of your job, do you produce technical messages to explain situations to people with the same or nearly the same knowledge as yourself of your technical area?

	YES	*Please tick relevant boxes*	NO
1		Papers for publication in scientific/engineering journals.	*go to (b)*
2		Reports on scientific/engineering investigations relating to process development, product development, market development, fault diagnosis etc.	
3		Reports on special tests and surveys with your interpretation of the results.	
4		Lectures or talks on above types of activity.	
5		Demonstrations connected with above types of activity.	
6		Contributions to discussions on papers, reports, lectures given by others on above types of activity.	
7		Written reports from testing state of materials; physical, metallurgical, etc.	
8		Written reports from observed state of objects or systems; surveys, inspections, etc.	
9		Written reports on observed operating conditions; operating logs, production reports, activity and progress reports, operating costs, production costs etc.	
10		Other types of message (please specify types)	

.....

(b) Do you produce written technical messages describing results you have measured or observed to people who have more knowledge than yourself of your technical area, and who interpret the meaning of your results?

	YES	*Please tick relevant boxes*	NO
1		Reports from testing state of material; physical, metallurgical, etc.	*go to (c)*
2		Reports from observed state of objects or systems; surveys, inspections etc.	
3		Reports on observed operating conditions; operating logs, production reports, activity and progress reports, operating costs, production costs	
4		Other types of message (please specify types)	

.....

(c) As part of your job, do you produce technical messages to explain situations to people with some knowledge, but less than yourself, of your technical area?

NO ☐ *go to (d)*

	YES	*Please tick relevant boxes*
1	☐	Specifications of materials, objects, systems.
2	☐	Working drawings.
3	☐	Flow charts - for computer systems, work systems etc.
4	☐	Procedures - instruction manuals, work instruction sheets, etc.
5	☐	Schedules - production, maintenance etc.
6	☐	Lists - material requirements, costs, etc.
7	☐	Sketches, diagrams, graphs.
8	☐	Quotations, tenders, estimates.
9	☐	Brochures, leaflets - Technical sales.
10	☐	Demonstrations - to customers or potential customers
11	☐	Demonstrations - to employees of your firm.
12	☐	Lectures or talks.
13	☐	Written reports from testing state of materials; physical, metallurgical etc.
14	☐	Written reports from observed state of objects or systems; surveys, inspections, etc.
15	☐	Written reports on observed operating conditions; operating logs, production reports, activity and progress reports, operating costs, production costs, etc.
16	☐	Other types of message (please specify types)

.....

(d) Do you produce messages to explain technical situations to people with little or no knowledge of your technical area?

NO ☐ *Please turn over*

	YES	I write letters to	I give demonstrations to	I give lectures or talks to	I have interviews with	I write reports to	*Please tick relevant boxes*
1	☐	☐	☐	☐	☐	☐	The general public
2	☐	☐	☐	☐	☐	☐	Customers or potential customers
3	☐	☐	☐	☐	☐	☐	Employees or potential employees
4	☐	☐	☐	☐	☐	☐	Lawyers, accountants, statutory agencies, Government departments, etc.
5	☐	☐	☐	☐	☐	☐	Board of Directors
6	☐	☐	☐	☐	☐	☐	Others (please specify people): .....

Q.11 Controlling Task

DEFINITION: *The observation of your own or other people's behaviour, or the performance of technical equipment, and the inference and implementation of adjustments to correct deviations from the intended results.*

(a) Which of the following factors do you measure or monitor in your present job?
Please tick relevant boxes

		Cost of	Quality of	Quantity of	Timing of
1	Input to you, i.e. the materials, messages, etc. you receive to work on or with				
2	Output from you, i.e. the materials, messages, etc. you produce				
3	Work input to other people in the firm				
4	Work output from other people in the firm				
5	Equipment you use - cost of running or quality of				
6	Equipment you use - cost of maintaining				
7	Equipment other people in the firm use - cost of running or quality of				
8	Equipment other people in the firm use - cost of maintaining				
9	Other (please specify factors):				

(b) When those factors which you measure or monitor have been outside acceptable limits, which of the following actions have you taken?
You may tick more than one box for each action, if applicable.

	According to my own experience I	According to written rules or procedures or to rules laid down by a superior in the firm I	
1			reorganised the group of people or specified how to reorganise the group of people (by recommendation, request or command) to achieve the intended results
2			revised the intended results or specified how to revise the intended results to bring them into line with what was actually happening
3			changed or modified the technical equipment or specified how to change or modify the technical equipment to increase productivity
4			trained/instructed the people causing the deviation or specified how they should be trained/instructed

5 ☐ None of the above

PART B

Some of the tasks in this part may not be applicable to your job, if this is so, please follow the arrows from the NO boxes.

Q.12 Manipulative Tasks

(a) Do you use, have to know how to use or need an appreciation of the use of instruments, manufacturing plant, machinery or special purpose equipment in your present job?

If YES continue to Q.12(b) ☐ Yes ☐ No *If NO go to Q.13*

(b) Types of Manipulative Tasks
Please tick relevant boxes

	I perform this task with skill in my present job.	I have to know how to perform this task to be competent in my present job	I need an appreciation of this task to be competent in my present job	
1	☐	☐	☐	using drawing equipment
2	☐	☐	☐	using calculating instruments
3	☐	☐	☐	calibrating or using measuring instruments
4	☐	☐	☐	using other instruments (please specify instrument type) .....
5	☐	☐	☐	repairing or maintaining measuring instruments
6	☐	☐	☐	repairing or maintaining other instruments (please specify instrument type) .....
7	☐	☐	☐	using hand tools
8	☐	☐	☐	using press tools, moulds and dies
9	☐	☐	☐	using jigs and fixtures
10	☐	☐	☐	using machine cutting tools, e.g. form tools, broaches, milling cutters, thread and gear cutters
11	☐	☐	☐	operating power generating plant
12	☐	☐	☐	operating process plant
13	☐	☐	☐	operating special purpose equipment e.g. research rigs, development rigs (please specify equipment types) .....
14	☐	☐	☐	other manipulative situations (please specify type of situation) .....

Question 12 Continued

(c) Knowledge of measuring instruments

Do you use, have to know how to use, or need an appreciation of the use of measuring instruments?

☐ YES ☐ NO

go to Q.13

Please tick relevant boxes.
Note: the headings refer to the 'operating principle' of the instrument, i.e. how the instrument works, and not to the parameter being measured, e.g. an electrically operated petrol gauge would be classified as 'electrical' and not fluid.

	I use this type of measuring instrument with skill in my present job.	I have to know how to use this type of measuring instrument to be competent in my present job	I need an appreciation of the use of this type of measuring instrument to be competent in my present job	Please give examples
1				Electrical, e.g. _____
2				Electronic, e.g. _____
3				Magnetic, e.g. _____
4				Mechanical, e.g. _____
5				Chemical, e.g. _____
6				Optical, e.g. _____
7				Thermal, e.g. _____
8				Fluid, e.g. _____
9				Radiative, e.g. _____
10				Ionisation e.g. _____

Q.13. Planning Task

DEFINITION: *The production of a message describing the action or results you intend a group of people to produce at some future time.*

(a) As part of your job, do you plan: the work of individual personnel in the firm; the objectives or expected performance of a section, department, division of the firm; or the objectives or expected performance of the firm as a whole?

NO ☐ *go to Q.14 on next page*

If your answer is YES please indicate the types of plan you produce and the time-periods you look ahead in producing those plans by ticking the relevant boxes. If you plan for more than 3 years ahead please specify maximum time-period you look ahead. (You may tick more than one box for each type of plan, if applicable).

YES

	Time period you look ahead to produce plans			Types of plan you produce
	Up to 1 yr	Over 1 yr, up to 3 yrs	Over 3 yrs (please specify max. time-period you look ahead)	
1			☒	*Plans for individual personnel or sections of the firm*, i.e. statements outlining the performance or behaviour expected of individual personnel or a part of a major function of the firm. For example: workshop schedules, material purchase budgets, salesmen's targets
2			...years	*Plans for a major function of the firm (e.g. production, personnel, research, marketing, finance etc.)* i.e. statements outlining the objectives of, expected performance of, or resource allocation within a major function of the firm. For example: production budgets, marketing plans.
3			...years	*Plans for resource acquisition or allocation for the firm as a whole*, i.e. statements outlining the amount and type of each resource (i.e. money, facilities, equipment, materials, supplies, services or personnel) that will be required by the firm or the allocation of those resources to the major functions of the firm (these plans include most or all of the major functions). For example: personnel recruitment policies, equipment maintenance or replacement policies, financial budgeting for firm as a whole.
4			...years	*Plans outlining the objectives of the firm as a whole* i.e. statements outlining the purpose, aims, goals, objectives of the firm as a whole or what the company might/should be like at some future date (these plans include most or all of the major functions). For example: scenarios (statements about what kind of business the firm would like to be in and the way in which its business is to be conducted), statements regarding the firm's performance objectives (e.g. profit to be earned at some specified date).

Question 13 continued

(b) Please name the groups you plan for.

Name of Group	No. of people in group (if known

Q.14 Designing Task

DEFINITION: *The production of a message describing the essential features of a new object/system/procedure/method so that it can be produced.*

(a) Do you design in your present job?

YES ☐ NO ☐ *go to Q.15*

(b) Design Level

Please indicate which of the following messages you receive or produce by ticking the relevant boxes

	I receive messages which describe	I produce messages which describe	
1	☒	☐	*a detailed specification of the new object/system/procedure/method.* For example: detailed working drawings of objects, computer programs, operation charts, sampling designs, designs of experiments.
2	☐	☐	*an outline specification of the new object/system/procedure/method giving the values of the main variables.* For example: a structural description of an object/system (what it should look like), such as assembly drawings; a statement outlining the main elements of a procedure/method, such as process charts, flow charts; computer flow charts.
3	☐	☐	*the performance of the new object/system/procedure/method,* (i.e. what it should do). For example: a functional specification of an object/system; the aim, purpose, objective of a procedure/method.
4	☐	☒	*a problem situation which requires the design or redesign (modification) of an object/system/procedure/method to solve it.*

Question 14 continued

(c) Please indicate which of the following objects/systems/procedures/methods you design by ticking the relevant boxes.

Objects/systems

1	☐	jigs, tools, fixtures, etc.
2	☐	instruments
3	☐	mechanical components and machines
4	☐	electrical/electronic components and circuits
5	☐	structures
6	☐	chemical plant
7	☐	factory or departmental layout
8	☐	other (please specify):

.....

.....

Procedures/methods

9	☐	computer programs
10	☐	computer software systems
11	☐	administrative procedures, e.g. cost control procedures
12	☐	planning procedures
13	☐	design procedures
14	☐	production or test procedures or work methods
15	☐	organisational structure of firm
16	☐	other (please specify):

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Q.15 Negotiating Task

DEFINITION: *Bargaining for the exchange of valued possessions, as a principal or as an agent of the firm.*

(a) As part of your job, do you negotiate contracts or agreements on behalf of the firm?

(Please answer this question if you negotiate contracts on behalf of the firm whether or not you sign or authorise those contracts)

☐ YES ☐ NO

go to Q.16

(b) I negotiate contracts or agreements with:

1	☐	Suppliers of services, e.g. transporters, advertisers, personnel consultants.
2	☐	Suppliers of materials, energy, partly finished goods or components
3	☐	Suppliers of capital (e.g. banks, finance houses, etc.)
4	☐	Suppliers of machinery for making the firm's products
5	☐	Suppliers of tools, jigs and fixtures for making the firm's products
6	☐	Suppliers of proven designs or proven process know how, e.g. overseas licensors
7	☐	Trade Unions
8	☐	Employees not in Trade Unions
9	☐	Professional consultants working on the firm's problems
10	☐	Customers and potential customers
11	☐	Licensees of the firm's designs, products or other technical know how
12	☐	Government agencies, local bodies, and other statutory organisations
13	☐	Others - please specify

.....

Q.16 Organising Task

DEFINITION: The allocation or assignment of tasks to people and the co-ordination and integration of their behaviour.

(a) As part of your job, do you organise a group of people in your firm?

NO

YES

Name of Group	No. of people in group (if known)

(b) Are there other sections, departments, divisions, etc. in the firm which you don't organise, but for which you have to know how they are organised to be competent in your work?

NO

YES

Name of Group	No. of people in group (if known)

END

THE BEGINNING

E R R A T A

Page No.	Paragraph	Line	
21	2	7	"phenoma" should be "phenomena"
70	3	3 and 6	"Vj_B" should be "Vj_{B_1}"
86	5	6	"goups" should be "groups"
134	2	1	"where" should be "whose"